RESPONSE OF PEACH TREES TO NITROGEN AND WEED MANAGEMENT PRACTICES

THESIS

By

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CERTIFICATE-I

This is to certify that the thesis entitled " Response of peach trees to nitrogen fertilization and weed management practices" submitted in partial fulfilment of the requirement for the degree of DOCTOR OF PHILOSOPHY IN HORTICULTURE(Pomology and Fruit Technology) of the Dr Yashwant Singh Parmar University of Horticulture and Forestry, is a faithful record of bonafide research work carried out by Shri Yash Pal Sharma under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation and the source of literature have been fully acknowledged.

Dated: July 25,1987

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CERTIFICATE- II

This is to certify that the thesis entitled " Response of peach trees to nitrogen fertilization and weed management practices" submitted by Shri Yash Pal Sharma to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN HORTICULTURE(Pomology and Fruit Technology) has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with External Examiner.

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CONTENTS

ABBREVIATION USED

N	Nitrogen
N_0	No nitrogen
N_1	200 g N $tree^{-1}$
N_2	400 g N $tree^{-1}$
M_0	No weed management practices
M_1	Atrazine @ 4Kg ha^{-1}
M_2	Oxyfluorfen 0.3Kg ha^{-1}
M_3	Diuron @ 4Kg ha^{-1}
M_4	Dry grass 10 cm thick layer
M_5	Black polythene mulch of 14 mm thickness

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CHAPTER - I

INTRODUCTION

INTRODUCTION

Peach (*Prunus persica* Batsch.) is one of the most important stone fruit of the world. Until recently the cultivation of peach had remained confined to the mid and high hill areas of Himalayan region of India. However, with the introduction of high yielding subtropical peaches, the cultivation of this fruit has been extended to the plains and foot hill regions of north India and has assumed commercial importance. The peach cultivar 16-33 commonly known as Shan-e-Punjab has been found to be a prolific regular bearer with excellent fruit quality and as such has been recommended for cultivation in the plains of Punjab, Haryana and the low hills and valley areas of Himachal Pradesh.

Among many factors, proper fertilization is of prime importance for obtaining optimum growth and yield of high quality fruits. Among different nutrient elements, N has long been considered a dominant nutritional factor for growth, development and productivity of the fruit plants. Therefore, it is important to work out suitable dose of N that will maintain the vigour and productivity of the trees.

Application of liberal amount of fertilizers is known to increase weed population in orchards. A good portion of the input is taken up by the weeds depriving the fruit trees of the benefits of this expensive input. Weed management practices including mulching exert a profound influence on the availability and uptake of nutrients by reducing the competition for nutrients by weeds and through improvement of physical condition of the soil moisture and temperature. Under mulching, weeds are controlled by etiolation and acts as a physical barrier for the newly emerging weeds.

The conventional method of hand weeding is costly and at times injurious to the surface feeder roots of fruit plants. In recent years, more emphasis has been laid on the scientific use of herbicides and mulches for the control of weeds than ever before. These weed management practices ensure development of an undisturbed soil profile and surface feeder roots(Atkinson,1977), improvement of soil nutrient status (Gaziev,1979), and soil moisture conservation (Hance,1976). Besides influencing tree growth and productivity, it reduces expenditure on fertilizers, irrigation and saves time on other management practices(Robinson,1982). Processes such as ammonification and nitrification are also influenced by these management practices (Ries et al.,1963) which also exercise stimulatory and inhibitory effect on soil microflora (Bhutani et al., 1984). The need for research on suitable weed management practices in relation to fertilizer use can hardly be over-emphasized for maximization of growth and productivity of fruit trees.

No systemic work has been conducted on the effect of N fertilization and weed management practices on the growth and cropping of Shan-e-Punjab cultivar of peach which is a recent introduction in the subtropical region of Himachal Pradesh. With these objectives in view, the present investigations were undertaken to study the influence of N and weed management practices on the tree productivity , fruit quality and nutrient status of young Shan-e-Punjab peach trees. The influence on weed population, nutrient removal by weeds, available nutrient status of soil, mineralizatin of N and changes in soil microflora were also examined in response to N application and weed management practices.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Nutrition plays a key role in the growth and productivity of fruit trees. Among the different nutrient elements, N is the most limiting and is generally required in greater amounts than P,K and other nutrients. Although the availability and uptake of N is influenced by a number of factors, weed management occupies a significant place. The weed management practices improve the soil texture thereby influence tree root system and nutrient uptake. Though the available literature of peach nutrition is well documented but the information of interaction of N nutrition and the weed management practices is lacking. Available literature on the effects of N and weed management practices on different parameters have been reviewed under appropriate heads.

2.1 Nitrogen

The large amount of N required by the plants is of special significance in fruit culture. A small shift in the amount of N in the tissues has a greater effect on growth and yield of the fruit plants. Thus sufficient N supply must be ensured for optimum growth, development and productivity of the fruit trees.

2.1.1 Effect on growth and vigour

Many investigators recorded increase in trunk girth of peach trees by the application of N (McMunn,1933, Ritter

1965; Baroccio and Manzo,1966). Studies of Armstron (1966) have revealed that N fertilization alone or in combination with P and K exert a great influence on trunk diameter of Elberta peach.

The effect of N on increasing the vegetative growth of stone fruits is very well demonstrated. A proportionate increase in extension shoot growth and tree circumference with increased N levels in different peach cultivars have been reported by various researchers(Baxter,1974;Lenina et al.1977; Tawfik et al.1974; Sharma et al.1979). Monastra et al.(1975) found maximum tree growth response in peaches to applied nitrogen upto 180 Kg ha^{-1},whereas no additional response was observed with 300 Kg N ha^{-1}. In case of Sharbati cultivar of peach,120 g N per year age of plant produced the highest growth as compared to two lower levels (Sharma and Singh,1982). Kanwar (1979) while working on Flordasun peach found that 1.50 Kg N $tree^{-1}$ produced significantly higher trunk girth as compared to lower doses of 0.5 and 1.0 Kg of N. He further observed that application of N had no effect on pruning weight and extension growth.

2.1.2 Effect of yield

Adequate amount of N is required to obtain good yield of fruit crops. Higher rate of N increased yield in peaches (Cahoon,1971; Uchiyama,1973;Orphanos,1974; Baxter,1974;Lenina et al.1977; El-Banna et al.1981).

On the other hand Ballinger et al.(1963) and Rogers(1971) observed no effect of N application on the yield of peach trees.

Kanwar (1979) obtained the best yield in Flordasun peach by applying 1000,500,500 g tree^{-1} of N, P_2O_5 and K_2O respectively. Similarly Yamdagni and Jindal (1979) also obtained marked yield response in Sharbati peaches when NPK were applied at 400,100 and 400 g tree^{-1} respectively.

2.1.3 Effect on fruit attributes

Application of N fertilizers in fruit trees have been found to exert a considerable influence on fruit size and other attributes. The increase in fruit size as a result of N application have been reported by various researchers(Moury,1963; Kwong and Fisher,1962; Brown and Proebsting,1962). Sharma (1976) also observed increase in fruit size in peaches by increasing the rate of N application. Contrary to it, Schneider and McClung(1957) and Ballinger et al.(1963) did not observe the effect of N fertilization on the fruit size in peaches. Sharma et al.(1979) reported that application of N,P_2O_5 and K_2O in the ratio of 450:75: 300 g tree^{-1} tend to increase fruit size, weight and volume of the Sharbati peach. Ritter (1961) observed that graded levels of P applications increased total soluble solids but reduced the flavour in Elberta peaches. However, Nijjar et al.(1972) and Sharma (1976) did not observe effect of N application on TSS and titratable acid contents in apricot and peaches.

2.1.4 Effect on tree nutrient status

Evidences are available to suggest that the nutrient status of fruit trees is greatly influenced by the presence of various nutrients in the soil and N fertilizers play a vital role. Ritter (1965) observed an increase in leaf N and Mn by the addition of successively large application of N fertilizers to Elberta peach. Application of N appeared to have increased the effectiveness of the trees in absorbing and utilizing the available K and Mn compared with check trees.

A positive relationship between the rate of N fertilization and leaf N status; and a negative between N and leaf K status was observed by Stembridge et al.(1962) in Dixigen peaches. Similarly Stojkovska et al.(1972) found a direct increase in leaf N,P and K contents of peach trees with increased levels of N,P and K fertilizers application to the soil. Lesce (1976) reported that application of N fertilizers to peach trees resulted in an increased concentration of leaf N,Fe,Cu,Mn and Zn while K,Ca,Mg and B decreased. Gammon and Shoemaker(1964) reported that increasing N rate in peach increased N and Ca contents of leaves and decreased P and K.

No evidence is available to suggest the nutrient status of peach fruit. However, Sud (1987) observed that N application through soil and foliage in apricot orchard enhanced fruit N and Fe while decreased Ca and Zn without altering P,K and Cu.

2.1.5 <u>Effect on physico-chemical properties of soil</u>

Due to high intensity cropping and excessive use of fertilizers it has become more important to assess the changes in soil properties. Out of N fertilizers,ammonium sulphate (Aquino et al.1976 and Sinha et al.1983) and ammonium phosphate (Aquino et al.1976) have been observed to cause a drastic reduction in soil pH as compared to urea, whereas calcium nitrate and sodium nitrate proved ineffective. Bhatia (1982) demonstrated that soil pH and electrical conductivity of Santa Rosa plum orchard decreased with the application of N and were noticed to be higher with increased soil depth. Similar reduction in soil pH and electrical conductivity in plum orchard have been reported by Badyal (1980) and Khokhar(1984). Sud (1987) reported decrease in soil pH with increased N fertilization, though its level was higher in the deeper soil segments. However, Chandel(1985) did not find the influence of depth on soil pH in apricot. Organic carbon contents on the other hand, have been reported to increase with increased N levels(Badyal,1980; Bhatia,1982; Khokhar,1984) and decreased with increased soil depth.

2.1.6 Effect on nutrient status of soil

Information regarding the effect of fertilizers on nutrient availability particularly in orchard soil is lacking. An increase in the available and total N in the soil has been reported with application of N to the soil by Vitanova (1973) in plum orchard. Bhatia (1982), Khokhar (1984) and Bhan (1986) observed an increase in available N levels by increasing N doses in plum orchard. Chandel (1985) reported increase in available N,K and decrease in P content of soil with the increased levels of N in apricot. While Sud(1987) reported that increased N rate increased the level of available N,K and Mg while exchangeable Ca did not alter with enhanced N supply. The available nutrient status decreased with increased soil depth.

The decrease of soil K content by N has been reported by Cummings (1978) and Kepka et al.(1982). The decrease of soil K have resulted from NH_4^+ replacing K on the exchange comolex resulting in leaching of K. Muthuel et al.(1979) and Bansal et al.(1980) reported that the increasing doses of N,P and their combinations increased the total N content in upper soil layer. But, even lower depths upto one meter could bring N enrichment by increasing N levels (Lecknova, 1978).

2.1.7 Effect on soil nitrification

Ammonium and nitrate N availability in the soil is considered to be the best index of determining soil fertility as the plant absorbs most of their N in NH_4-N and No_3-N forms (Tisdale and Nelson,1975). About 30-50 per cent increase in No_3-N content was reported by the application of N (Sanoilenka 1973). Reichlova (1975) found greater rate of nitrification process compared to control when soil was applied with 2 ppm of ammonium sulphate. Various sources of N stimulated the process of nitrification and had varied rate of nitrification and mineralisation of total N (Joshi et al. 1976). Bhan (1986) reported maximum NH_4-N in plum orchard soil receiving 750 g N $tree^{-1}$.

2.1.8 Effect on soil microflora

Microorganisms living in the surface soil horizons play a vital role in the maintenance of soil fertility and crop productivity. Collective information on soil microorganisms following change in the soil environment or soil treatment may have marked effect on fertility status of the soil. An application of organic manures and organic matter in the form of compost or FYM or green manure to soil has been reported to increase the population of bacteria actinomycetes and fungi(Jha,1965; Gupta,1967; Balasubramaniam et al. 1972).

According to Bagyaraj and Rangaswami(1967), the microbial population and their activities are directly influenced by the application of fertilizers and organic manures. Application of NPK fertilizers has been observed to increase the number of soil bacteria and their activities (Koshar et al. 1976) and cellulolytic bacteria and cellulose decomposing activity in the soil (Todorova, 1972). Badve and Konde (1977) reported that application of nitrogenous fertilizers upto a certain extent increased azotobactor population and their atmospheric nitrogen fixing ability. An increase in fungi population by increasing N levels has been reported by Bhutani and Bhatia (1985) in plum orchard soil. Gupta et al.(1983) found that the use of ammonium sulphate decreased the rate of nitrification particularly by nitrobactor as a result of decreased pH by the fertilizer. However, the treatment of organic manure enhanced microbial number and activities. An increase in the microflora particularly actinomycetes and fungi was observed by the application of N and K in plum orchard by Khokhar (1984) and Bhan (1985). Sud (1987) reported that N application showed pronounced influence on the soil microbial activity. Bacterial and fungal population was stimulated with increase N dose upto 45 days and then declined gradually. In case of actinomycetes, the stimulatory influence was observed with 400 g N and the stimulator effect lasted upto 15 days of N application.

2.2 Weed management practices

Practice of weed control is almost as old as agriculture. Since earliest recorded history, methods of weed control have been largely non-chemical. All these methods such as ploughing, hoeing, burning, hand pulling and mulching are still in vogue. Single weed control practices are not enough for all cases. It should be a combination of cultural, mechanical, biological and chemical practices that are effective to improve the farmers socio-economic resources.

2.2.1 Effect on weed flora

Attempts are often made to control weeds by mulching with straw, hay, manure, plastic film and rice hulls. The objective is completely to exclude the light and thus prevent all top growth. Jayant (1984) observed a decrease in weed population by the use of hay mulching or mulching plus herbicide in plum orchard. Nayital et al.(1986) found that black polythene mulching in Santa Rosa plum orchard decreased weed population compared to control. Sharma (1985) also obtained a decrease in monocot and dicot weed population by the application of mulching or herbicide alone or with combination treatments in apricot orchard.

Though a large number of herbicides have been studied in stone fruit orchards but a large number of researchers have recommended the use of triazines or substituted ureas for obtaining an effective weed control (Trifonov,1962; Ries et al. 1963; Nicolli et al.1973; Bhan, 1982; Bhutani and Bhatia,1984). Daniell and Hardcastle(1969) while working on young peach trees with various herbicides stated that in fine sandy loam soils simazine at 4 lb $acre^{-1}$, paraquat at 0.5 lb $acre^{-1}$ applied thrice and dichlobenil at 3 and 6 lb $acre^{-1}$ produced an excellent weed control. Dolby and Putnam (1980) reported good control of weeds by the application of oxyfluorfen at 2.2 Kg ha^{-1} in peach and apple orchard. Daniell (1981) also found oxyfluorfen quite effective in controlling weeds in peaches. West et al. (1983) found that oxyflourfen plus glyphosate provided an excellent short term broad spectrum control of summar annual weeds in stone fruits. Khan (1986) reported that weed population was significantly reduced by the application of diuron or atrazine. He further observed that diuron asserted its superiority over atrazine in controlling weed population. Sharma (1986) reported that atrazine or diuron at 5 and 6 Kg ha^{-1} respectively and oxyfluorfen at 0.2 and 0.3 kg ha^{-1} reduced the monocot and dicot weed population in peach orchard.

2.2.2 Effect on nutrient removal by weeds

Weed management practices improve soil fertility directly by conserving the nutrients and also suppressing their uptake by weeds. Jayant (1984) reported reduction in losses of macro and micronutrient by weeds due to application of herbicide and mulching plus herbicide compared to clean cultivation, green manuring and intercropping. A judicious use of herbicides is reported to minimise the removal of nutrients by weeds (Halliday,1975; Mani et al.1976;

Pillai et al.1976). The nutrient loss by weed was also found to be lowered following the use of herb icides mainly due to efficient weed control by Bhan et al.(1982) and Bhatia (1982) in plum orchard. Likewise Sharma (1986) observed that all levels of atrazine, diuron (4,5 and 6 Kg ha^{-1}),oxyflurofen (0.1 ,0.2 and 0.3 Kg ha^{-1}) and higher doses of isoproturon (5 and 6 Kg ha^{-1}) reduced the loss of both macro and micronutrient by weeds.

2.2.3 Effect on growth and vigour

Mulching has been reported to induce better growth of trees than clean cultivation (Adamic, 1964; Moss,1969; Fideghelli et al.1975). Mulching with leaves was recommended by Krishnamurthi (1959) as a standard practice for north India to tide over high temperature and rapid evaporation of soil moisture on account of high atmospheric temperature and low humidity. Cockroft and Tisdall(1974) observed the best tree growth of peach under straw mulch as indicated by trunk circumference and pruning weight. Ries et al.(1963) showed that peach and apple trees grew more when weeds were controlled with simazine compared to black alkathene mulch or hoeing. They further found that simazine plus amitrole increased the growth and development of the terminal branches in peach and apple trees as compared to unweeded control. Daniell and Hardcastle (1969) have also found that peach trees grew as good as or better than harrowed control, when weeds were controlled with herbicides.

In South Central Victoria (Australia) where summers are dry, Baxter(1970) observed higher growth and yield under straw mulch in peach compared to herbicides and sod culture. Chiba et al.(1975) while comparing the four soil management systems observed that straw mulch and clean cultivation had the best growth in peaches as compared to grass or weed sward. Black alkathene mulch resulted in increased trunk circumference, shoot growth and number of bearing branches in pear and peach compared to clean cultivation(Bacon,1974; Rahovic,1976; Rahovic; Petrovic,1977).

Jayant(1984) reported that growth in terms of per cent increase in trunk girth, shoot length was highest with herbicide treatment followed by mulching plus herbicides in plum orchard. Sharma (1985) also recorded highest increase in trunk girth, extension shoot growth with mulching plus simazine plus glyphosate treatment followed by mulching plus glyphosate, mulching alone and mulching plus simazine.

The overall weed free system managed by herbicides allows more extension root development with a better utilization of top soil moisture and available nutrients, resulting into faster development of the tree(Robinson,1974). A lot of work carried out in U.K. (Atkinson et al.1982) led to the conclusion that overall herbicide systems produced best tree growth as compared to clean cultivation and grass sward. Effect of weedicides in increasing tree growth has been attributed to increase in N absorption or its metabolism. Various other researchers have also reported pronounced effect of herbicides on growth and vigour of stone fruit trees(Goren and Monselies,1966; Stott,1969; Lord and Vlach,1972). The growth of peach seedlings and peach trees have been reported to increase by oryzalin, simazine and paraquat herbicidal treatments(Curtis,1974; Koffmann and Koldar, 1975; Arnold and Aldrich,1980; Young, 1980). Sharma (1985) reported that among all the herbicides used only diuron at 5 kg ha^{-1} was found to cause an increase in trunk girth of peach trees. However, many reports did not show any difference in growth of peach trees by application of diuron, simazine, oryzalina and paraquat(Chiusoli,1971; Rom et al.1978; Young and Walker,1981).

2.2.4 Effect on yield

A significant increase in fruit yield has been reported by polythene mulching in peach orchard(Chadha et al. 1966;Rahovic and Patrovic,1977). Black polythene mulch placed around trickle irrigated apple, peach and orange trees increased the yield by 16,10 and 36 per cent respectively(Bacon,1974). Studies conducted by Fideghelli et al.(1975) revealed that straw mulching in rows and chemical weed control between rows resulted in highest yield as compared to cultivation in Red Haven peaches.

An increase in yield in stone fruits have been reported following the application of herbicides such as bromacil, simazine, terbacil, monlinuron and diuron singly or in combination with other herbicides (Vuleva and Vulev,1980; Bhutani et al.1983; Khokhar,1984; Bhan, 1986). Jayant (1984) recorded highest yield with herbicide treatment followed by mulching plus herbicide in plum orchard, However, Dhuria et al.(1976), Fryer et al. (1979) and Bhatia (1982) did not find any influence on yield of plum with the application of herbicides. On the other hand, Gautam (1980) obtained decrease in yield of Santa Rosa plum following the long term use of herbicides.

2.2.5 Effect on fruit attributes

According to Werner (1978), permanent grass cover decreased the level of fruit acids but increase the percentage of total soluble solids. Black polythene mulch improved the fruit quality in respect of uniform fruits, maturity, size and colour of three pear and two peach cultivars compared to clean cultivated control(Rahovic and Petrovic,1977).

Jayant (1984) reported that herbicides and mulching plus herbicide increased fruit weight, volume, length and diameter of Santa Rosa plum. Sharma (1985) observed that fruit weight, length, total soluble solids, titratable acidity, reducing, non-reducing and total sugars were increased by the use of mulch material and herbicides as compared to unweeded control in apricot. Nayital et al. (1986) reported that various mulches improved fruit quality of plum cv. Santa Rosa compared to unweeded control.

Herbicides are known to have varying effect on fruit quality. Belyaeva and Zavarzin(1968) found an increase in vitamin C content and mono-saccharide levels of peach fruits by herbicide treatments, particularly monuron. Sharma(1986) reported that application of different herbicides increased fruit weight, volume, size, reducing sugars and ascorbic acid contents of July Elberta peaches. He also reported that nutrient status of peach fruit were not affected by atrazine, diuron,isoproturon and oxyfluorfen when applied at normal field rates.

2.2.6 <u>Effect on leaf nutrient status</u>

Leaf nutrient status of fruit trees is influenced considerably by the soil management practices and nutrition. Ries et al.(1963) reported that regardless of N level, the simazine increased the N content of peach trees. Lord and Vlach(1972) found that hay mulched peach trees had higher leaf K and lower Mg than the herbicide and clean cultivation treatments. Peach orchard periodically cleared off weeds with paraquat increased the N content in one-year-old shoots (Chiusoli,1971). In peaches, Fideghelli et al.(1975) also observed the best nutrient status of leaves especially for P and K under straw mulching and chemical weed control plots as compared to clean cultivation and mulch plus cultivation. Sharma

(1986) reported that leaf N of July Elberta peach increased by atrazine, diuron while oxyfluorfen proved comparatively ineffective. He further observed reduction in level of P by atrazine, diuron, isoproturon application. Leaf K, Ca and Mg was increased by all herbicides. Repeated annual application of simazine or terbacil in plum orchard improved leaf N, P, K, Ca, Fe, Mn but Mg and Zn remained unaffected (Bhatia, 1982). Khokhar (1984) recorded an increase in the leaf N, K, Ca and Mg by the use of atrazine and diuron in plum orchard. Jayant (1984) recorded highest N content under herbicide, however, mulching plus herbicide resulted in the highest P and K whereas Ca and Mg were not influenced by soil management practices. Cu and Zn were reported maximum with herbicide and mulching plus herbicide treatment.

2.2.7 Effect on physico-chemical properties of soil

The management practices effect physico-chemical properties of soil, directly or indirectly, which effect the tree productivity and fruit quality. The decrease in soil pH by the application of various herbicides have been reported by various workers (Atkinson and White, 1976; Haynes, 1980 and 1981 ; Johnson and Johnson 1982; Bhatia, 1982; Bhan, 1986). Jayant (1984) also observed that herbicides with or without mulch recorded reduction in pH in plum orchard soil. However, these findings did not have the support of Castro (1964), Nearpass (1965), Rao and

Bhutani (1977) and Khokhar (1984) who did not observe any measurable change in pH of orchard soil due to application of herbicides.

Khokhar (1984) and Jayant (1984) recorded an increase in organic carbon and electrical conductivity of plum orchard soil by the application of herbicides. Similar increase has been reported by Sharma(1985) in apricot orchard soil. Contrary to it Belobrov (1974), Rao and Bhutani (1977) and Bhan (1980) did not observe any change in electrical conductivity and organic carbon content of orchard soil by the application of herbicides and postulated that changes in such soil properties can be expected only after many years of herbicidal application.

2.2.8 Effect on nutrient status of soil

Weed management practices improve the nutrient status of soils which ultimately influence tree growth and productivity. Available N of soil was increased by green manure mulch in plum (Jayant,1984) and mulching plus simazine plus glyphosate in apricot (Sharma,1985). Jayant (1984) reported highest content of P,Ca and Mg with mulch plus herbicides. Sharma(1985) recorded highest P and K with mulching plus simazine and mulching plus glyphosate, respectively. Likewise an increase in P and K content of soil by straw mulch was recorded by Wander and Gourley(1938) and Wlodek and Wlodek (1955).

(1976) and Stancheva (1977) did not observe any adverse effect on ammonification and nitrification following the application of herbicides. Kollanikov and Sidorov(1978) reported that continuous use of herbicides increase the NO_3-N in the soil by controlling the weed population but simazine at 10 ppm inhibited the nitrification of soil. The increase in NH_4-N and No_3-N by the application of diuron has also been reported by Khokhar (1984) and Bhan (1986) in plum orchard.

2.2.10 Effect on soil microflora

Soil microflora generally control the decompostion and mineralisation processes in the soil, The destruction of beneficial microflora or shit in the balance of their population due to weed management practices may show marked effect on the soil fertility. Baklivanov and Karemidarska (1965) reported that mulching alone increase the total population of microorganisms as compared to clean cultivation plus NPK. Hacikjan (1968) recorded maximum numbers of microorganisms in the rhizosphere of clover used as a green manure compared with clean cultivation and sward. The improvement in microbiological regime of soil has also been noticed by Fisenko (1969) in clean cultivation followed by autumn sowing of pea-barley mixture with respect to clean cultivation and permanent grass. Stevenson and Chase(1957) reported that population of bacteria, fungus and actinomycates was not effected by mulch in peach orchard. Jayant (1984) reported that in plum orchard soil actinomycetes population increased with intercropping and decreased with herbcide and mulching plus herbicide.

Sharma (1986) found that fungi stimulated by atrazine and suppressed by diuron and oxyfluorfen but remained unaffected by isoproturon. Actinomycetes reduced by high doses of atrazine and oxyflurofen . Mashtakov et al.(1962) have observed in vitro and in vivo studies that growth of fungi,bacteria, actinomycetes and nitrogen fixing free living organisms was enhanced with the application of moderate doses of 2,4-D, atrazine and simazine. Akopyan and Karapetyan (1979) and Emtsev et al.(1982) observed that microflora activities in soil were stimulated with the application of S-triazines. Rao and Bhutani (1977) observed an increase in microbial population by the application of simazine, atrazine, diuron, bromocil and terbacil at normal field rates. Bhutani and Bhatia (1984) reported stimulation in bacterial population due to application of simazine and terbacil in plum orchard soil. They further observed that application of herbicides caused inhibitory effect on actinomycetes population, however, no effect on fungal population was recorded.

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigations were conducted at experimental orchard of the Department of Pomology and Fruit Technology, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur during 1985 and 1986. The experimental orchard is situated at 1250 m above mean sea level. The soil under the experiment had the following physico-chemical characteristic (Table 3.1).

Table 3.1: Physico-chemical analysis of soil of the experimental orchard

Particulars	Depth(cm)		
	0-15	15-30	30-60
Clay(%)	20.4	24.8	39.6
Silt(%)	52.8	50.6	39.6
Sand(%)	21.5	24.3	20.2
Texture	Loam	Loam	Clay loam
pH(1:2)	4.8	5.0	5.2
Organic carbon(%)	1.2	1.0	0.8
Available N(ppm)	70	60	40
Available P(ppm)	6.5	6.0	5.0
Available K(ppm)	115	100	75

The observations presented in Table 3.1 indicate that the texture of the soil was loam at surface and clay loam at the sub-surface level. The available K and organic carbon contents were medium,however, N and P were low in range. The soil was acidic in reaction.

Six-year-old Shan-e-Punjab peach trees, raised on wild peach and spaced at 5 x 5 m were selected for the present study. The experiment was laid out in split plot design during the first week of February, 1985 with 3 levels of N at 0,200 and 400 g tree^{-1} (N_0, N_1 and N_2) and six weed management practices-No weeding(M_0), atrazine at 4 kg ha^{-1} (M_1), oxyfluorfen at 0.3 Kg ha^{-1} (M_2), diuron at 4 kg ha^{-1} (M_3), 10 cm thick grass mulch (M_4) and polythene mulch(M_5). The levels of N comprised the main plot and the herbicide management system as subplot treatments.

In all there were eighteen single tree treatments replicated quadrately. The N was applied in the form of calcium ammonium nitrate in two split doses, first half of N alongwith basal dose of P_2O_5 and K_2O(250 and 600 g tree^{-1}, respectively) were applied in the second week of February and the second half of N was added in the second week of April.

The herbicides were applied annually as direct spray in the basin of 1.5 m radius around the tree as pre-emergence to weeds in the second week of April. Under grass mulch 10 cm thick dry grass and black polythene of 14 mm thickness were spread uniformly in the basins immediately after the application of first dose of fertilizer.The experimental tree were given uniform cultural operations such as pruning, irrigation, spray of insecticides and fungicides.

The studies conducted and procedures followed are detailed below:

3.1.1 Studies on weeds

3.1.1 Pre-dominant weed flora

Pre-dominant flora in the experimental orchard was identified and grouped into monocot and dicot, prior to herbicidal sprays.

3.1.2 Weed population

Before the emergence of weeds, a representative area of 1 x 1 m was marked at two locations randomly in the tree basin. The data on monocot and dicot weeds were recorded 30,60,90 and 120 days after application of herbicides and the population was expressed per square meter(m^{-2}). The data were analysed using $\sqrt{n+1}$ transformation.

3.1.3 Dry weight of weeds

After 120 days of herbicidal treatment, weed samples were collected randomly throwing a one square meter frame in the tree basin, weeds enclosed in the frame were uprooted, washed and dried in oven at 60°C for 48 hours. The data on dry weight of weeds were computed as $g\,m^{-1}$ and analysed using $\sqrt{n+1}$ transformation.

3.2 Nutrient removal by weeds

3.2.1 Collection of weed samples

The weed samples(whole plant) collected 120 days after treatment were washed thoroughly with tap water to remove any adhering soil particles and subsequent cleaning, drying, grinding and storing of samples were carried out according to the method suggested by Chapman (1964).

3.2.2 Digestion of weed samples

Well ground samples of known weight were digested for N estimation using concentrate H_2SO_4 and digestion catalyst as described by Jackson(1967). Separate digestion of plant material for other nutrient elements was done in diacid mixture(A.R. grade concentrate HNo_3 and $HClo_4$ in the ratio of 4:1) taking all relevant precautions as suggested by Piper(1966).

3.2.3 Nutrient estimation

Total N was estimated on Technicon autoanalyzer system II. Total P was determined by Vanadomolybdo phosphoric yellow colour method (Jackson,1967), whereas total K,Ca,Mg were estimated on Perkin Elmer atomic absorption spectrophotometer model 2380.

The nutrients removed by weeds were computed on dry weight basis and expressed as Kg ha^{-1}.

3.3 Tree productivity

3.3.1 Trunk girth

The trunk girth was measured 15 cm above the union in the last week of November 1985 and 1986 and expressed in cm.

3.3.2 Annual shoot extension

Ten shoots per experimental tree were selected all over the periphery of the tree before the start of growth and their extension growth was measured in January during both years.

3.3.3 Yield

The crop load removed from the tree during harvesting season of 1985 and 1986 were recorded and the results were expressed as yield in kg $tree^{-1}$.

3.4 Physico-chemical analysis of fruits

To determine the effect of various treatments on fruit quality and mineral composition, 2 kg representative samples were collected at harvest maturity and subjected to the following physico-chemical analyses.

3.4.1 Fruit weight

The weight of twenty fruits was taken on electronic top pan balance and the results were expressed as weight in g $fruit^{-1}$.

3.4.2 Fruit size

Fruit size of ten fruits were calculated by multiplying the average fruit length and breadth and expressed as fruit size in cm.

3.4.3 Fruit firmness

The firmness of five fruits was measured with the help of Effegi FT 011 penetrometer (Plunger diameter 7 mm), on both the cheeks of individual fruits and the readings recorded were averaged and expressed as kg.

3.4.4 Total soluble solids(TSS)

The TSS were recorded with Erma hand refractometer (0-32^{o}Brix) and calibrated at 20^{o}C (A.O.A.C. 1975). Readings recorded for each sample were averaged and expressed as per cent of fresh weight of juice.

3.4.5 Titratable acidity

25 g of fruit pulp was thoroughly mixed with distilled water in a waring blender, the volume was made to 250 ml. The solution was filtered through Whatman No.1 filter paper. 25 ml of this solution was titrated against N/10 NaOH using phenolphthalein as indicator. The total titratable acidity was calculated in terms of malic acid on the basis of 1 ml N/10 NaOH equivalent to 0.0067 g anhydrous malic acid. The results were expressed as per cent titratable acid on pulp weight basis.

3.4.6 Total sugars

To the remaining filtered stock solution(from 3.4.5) 10 ml of saturated lead acetate was added and volume made to 250 ml, then solution was filtered into flask containing potassium oxalate and the filtrate was again filtered. 100 ml of this deleaded and clarified solution was hydrolysed by adding 3 ml of concentrated HCl and leaving it overnight. The excess of HCl was neutralised by 10 per cent NaOH solution. The total sugars were estimated by titrating the boiling mixture containing 5 ml each of Fehling A and B solution against the hydrolysed aliquot(A.O.A.C.1975) and results were expressed as per cent on pulp weight basis.

3.4.7 Reducing sugars

Boiling mixture of 5 ml each of Fehling A and B solution were titrated against the remaining unhydrolysed, deleaded and clarified pulp solution. The results were expressed as per cent on pulp weight basis.

3.5 Leaf analysis

Leaf samples were collected from middle of the terminal shoot on the periphery of the trees as recommended by Kenowrthy (1964) during the second week of July,1985 and 1986. Cleaning, drying , griding and storing of the samples were carried out according to the procedure laid down by Chapman (1964).

3.5.1 Leaf nutrient estimation

The procedure followed for digestion of leaf samples and estimation of macronutrients were the same as described earlier for weed analysis under 3.2.2 and 3.2.3. Total Fe,Mn, Cu,and Zn contents were estimated on Perkin Elmer atomic absorption spectrophotometer model, 2380.

3.6 Fruit nutrients

The fruits were wahsed with distilled water and cut into pieces. 5 g fruit pulp was taken for estimation of nutrients. The procedure followed for digestion and estimation of total N,P,K, Ca,Mg,Fe,Mn,Zn and Cu were the same as discussed earlier for weed and leaf nutrient analysis. The results were expressed as mg 100 g^{-1} on pulp weight basis.

3.7 Soil analysis

3.7.1 Collection and preparation of soil samples

Soil samples representing 0-15,15-30 and 30-60 cm depth were collected from four sites of each experimental plot with the help of 1.5 cm screw auger during September 1985 and 1986. The samples were dried in shade, ground, passed through 2 mm plastic sieve and stored in cloth bags. The following determinations were carried out.

3.7.2 Soil pH

The pH was determined in 1:2 soil water suspension using Eltop digital pH meter.

3.7.3 Electrical conductivity

The electrical conductivity in the same soil water suspension was measured by systronics conductivity meter and the results were expressed in m mhos cm^{-1}.

3.7.4 Organic carbon

Organic carbon was determined by Walkley and Black rapid titration method as described by Piper(1966).

3.7.5 Available nitrogen

The available N was estimated by alkaline potassium permanganate method of Subhiah and Asija (1956).

3.7.6 Available phosphorus

The available P was extracted with 0.5 M $NaHCo_3$ adjusted at 8.5 pH and estimated by the method of Olsen et al.(1954).

3.7.7 Exchangeable potassium, calcium and magnesium

The exchangeable K,Ca and Mg were extracted with 1 N ammonium acetate and then estimated on Perkin Elmer atomic absorption spectrophotometer model 2380.

3.7.8 Soil nitrification

5 g air dried soil was shaken with 50 ml 1 N Na_2So_4 containing 45.0 mg ml^{-1} phenylmercuric acetate(PMA) solution for 30 minutes and filtered through Whatman No.1. The NH_4-N and No_3-N at different intervals were estimated as per method of Arthur and Sunderman (1977).

3.7.9 Soil microbial studies

Six random samples were drawn from 0-15 cm depth from the drip area of each tree at intervals of 1,30,60, 90 and 120 days of herbicide application during the year 1985 and 1986. The samples were pooled, mixed thoroughly and sub sampled. The composite samples were air dried, screened (20 mesh) and analysed for microbial population. Counts on bacteria, actinomycetes and fungi were made by dilution plate technique employing soil extract agar medium, ken knight agar medium and Martin's rose bengal agar medium, respectively, as suggested by Rangaswamy(1966).

3.8 Statistical analysis

The data generated from present investigations were subjected to statistical analysis in accordance with the procedure outlined by Chandel (1965). For statistical analysis split plot design was followed considering N levels as main treatments and weed management practices as sub treatments. Levels of significance used for 'F' and 't' were compared at $p = 0.05$.

The method described by Goulden (1952) was used to calculate correlation coefficient between leaf N v/s growth, fruit attributes and nutrient status of leaf. The similar procedure was followed for available N v/s growth, yield, quality and nutrient regime of soil.

CHAPTER - IV

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

The experimental results obtained from the present studies are presented as follows:

4.1 Weed studies

4.1.1 Survey of weed flora

A survey of weeds in the experimental orchard was carried out with a view to identify the predominant weed flora growing in the orchard and have been listed in Table 4.1

Table 4.1:Predominant weed species in peach orchard

Botanical name 1	Family 2	English / Common name 3	
A. Monocot			
Agropyron repens	Gramineae	Quack grass	-
Cynodon dactylon	Gramineae	Burmudagrass,	Doob
Cyperus rotundus	Gyperacea	Nutgrass,	Oila
Digitaria sanguinalis	Gramineae	Crab grass,	Takri Ghas
Echinochloa spp.	Gramineae	Barnyaed	Jungle rice
Imperata cylindrica	Gramineae	Thatch	-
Sachharum spontaneum	Gramineae	Sachharum	-
Suturia glauca	Gramineae	Yellow foxtail,	Banara
Sorghum halepense	Gramineae	Johnson grass,	Baru
B. Dicot			
Ageratum conyzoides	Compositeae	Billgoat weed,	Mahakana
Coronopus didymus	Cruciferaea	Ganduini	-
Chenopodium album	Chenopadiaceae	Doulamb bat,	Bathu
Convolulus arvensis	Convolvulaceae	Field, bind weed,	Hirankhuri
Euphorbia hirta	Euphorbiaceae	Pod spruge,	Bariduhi
Epilobium spp.	Papilionaceae	Fine weed,	-
Ipomoea spp.	Convolvulaceae	Morning glory,	Ivy leaf

1	2	3
Medicago spp	Papilionaceae	Alfalfa, Maina
Ranunculus muricatus	Ranunculaceae	- Jaldhar
Solanum nigrum	Solanaceae	Black night shade, Makoh
Sonchus arvensis	Compositeae	Milk weed, Daudhi

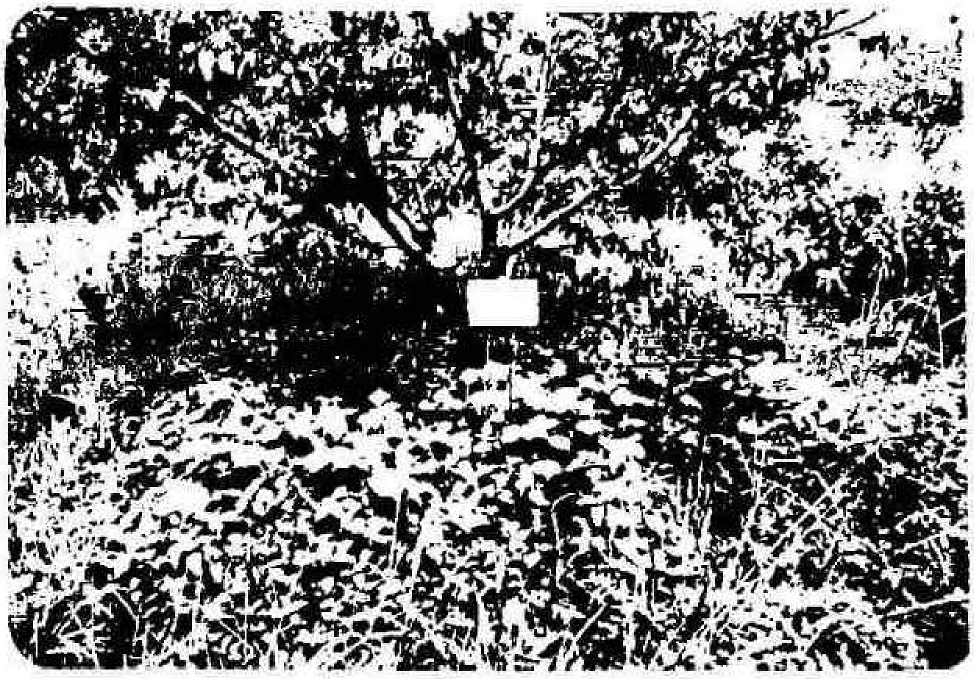
The major weed population consisted of *Imperata cylindrica*, *Cynodon dactylon*, *Cyperus rotundus*, *Sachharum spontaneum*, *Sorghum halepense*, *Ageratum conyzoides*, *Chenopodium album*, *Euphorbia hirta* and *Solanum nigrum* and represented about 80 per cent of the weed flora.

4.1.2 Weed population

Observations on number of weeds(m^{-2}) recorded 30, 60, 90 and 120 days of herbicidal treatments are presented in Table 4.2 and 4.3.

4.1.2.1 Monocot weeds

In general, all levels of N increased monocot weed population irrespective of weed management practices. In 1986 monocot weed population was not significantly influenced by N on first sampling date. Observations recorded 60 days after herbicidal application reveal that among various N doses, a higher weed count was recorded with 400 g N. At 90 days of application 200 g N though at par with 400 g N exhibited significantly higher weed count than the control(N_0). At 120 days of application, the differences



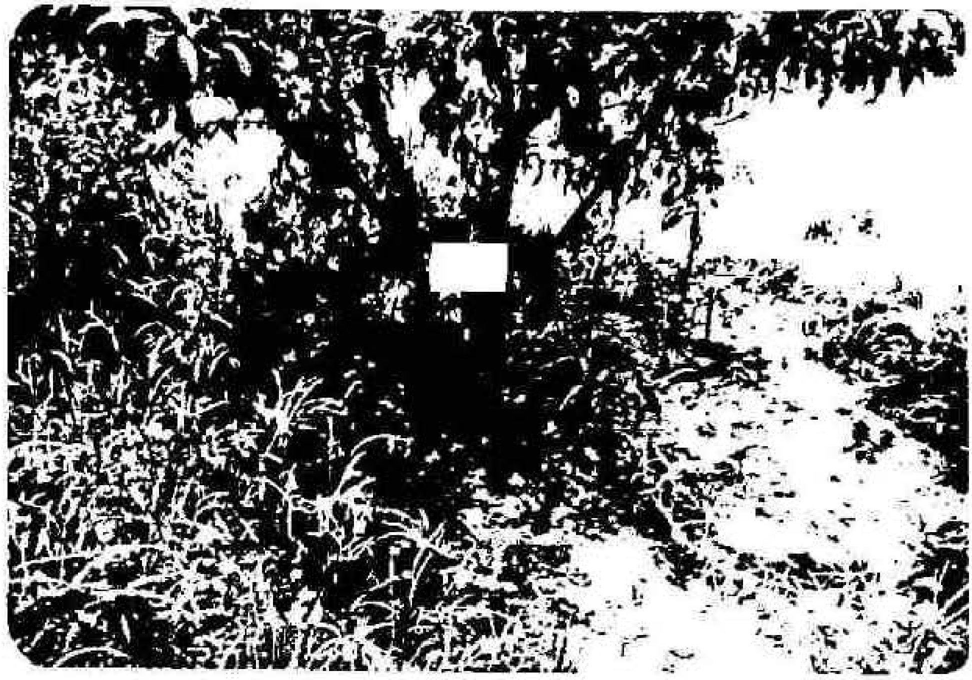


Table 4.2 : Effect of nitrogen and weed management practices on monocot weed population(m^{-2})

Treatment		Days after application							
		1985				1986			
		30	60	90	120	30	60	90	120
Nitrogen(g $tree^{-1}$) 0	(N_0)	8.8 (86.0)	9.8 (96.2)	10.2 (103.2)	12.4 (154.8)	6.6 (44.8)	6.8 (46.8)	7.2 (54.0)	14.0 (201.6)
200	(N_1)	9.8 (96.0)	10.0 (100.0)	10.6 (108.8)	12.6 (158.4)	7.2 (54.0)	7.4 (57.6)	7.9 (62.0)	14.6 (214.8)
400	(N_2)	10.8 (102.4)	10.8 (110.4)	10.6 (113.2)	12.8 (167.6	7.8 (62.0)	7.8 (62.8)	8.2 (67.2)	15.0 (220.0)
LSD (0.05)		NS	0.3	0.2	NS	0.5	0.2	0.4	0.4
Weed management practices									
Unweeded control	(M_0)	11.4 (135.6)	11.8 (143.2)	12.2 (147.6)	14.6 (213.2)	11.2 (122.8)	10.8 (116.8)	12.0 (128.0)	16.8 (281.2)
Atrazine	(M_1)	9.8 (102.8)	10.8 (113.2)	11.2 (122.8)	13.4 (177.2)	8.0 (62.0)	8.2 (65.2)	8.2 (64.0)	14.6 (218.4)
Oxyfluorfen	(M_2)	9.2 (84.8)	9.8 (89.6)	9.8 (90.8)	12.2 (148.4)	6.8 (43.2)	7.0 (46.8)	7.6 (54.4)	13.8 (188.8)
Diuron	(M_3)	9.0 (83.6)	9.4 (89.2)	9.6 (102.4)	12.0 (146.4)	5.6 (28.8)	5.8 (32.8)	5.8 (31.2)	13.8 (188.8)
Grass mulch	(M_4)	9.6 (92.8)	10.4 (106.0)	10.8 (112.0)	13.0 (168.0)	6.2 (32.8)	6.4 (42.8)	7.0 (46.4)	14.0 (212.4)
Polythene mulch	(M_5)	8.4 (70.8)	9.0 (77.6)	9.2 (82.8)	10.6 (112.8)	5.4 (27.6)	5.4 (28.8)	5.6 (29.2)	13.6 (186.0)
LSD (0.05)		0.1	0.6	0.5	0.5	0.6	0.7	0.4	1.2

Note: Figures in parentheses are original values, $\sqrt{n+1}$ transformation followed for statistical analysis in monocot weed population due to N levels were not significant. The differences in weed population due to N levels were significant at all the sampling dates in the year 1986. At 30 and 60 days, 400 g N exhibited significantly higher weed count than rest of the treatments. However, at 90 and 120 days, 200 g and 400 g N were at par but resulted in significant higher weed count. The minimum population was recorded in plots where no N was applied.

The weed management practices, regardless of N levels, reduced weed population significantly compared to unweeded control. The population was significantly higher under no weeding than other management practices. Black polythene mulch asserted its superiority over other management practices in controlling monocot weeds. Irrespective of N levels, the monocot weed population under different management practices decreased and the management practices followed the order of no weeding, atrazine application, grass mulching, oxyfluorfen and diuron treatment.

For both the years under study the interactions between N levels and weed management practices were found to be non-significant(Appendix-2).

4.1.2.2 Dicot weeds

As with monocot, a direct relationship was observed between N levels and dicot weed population irrespective of weed management practices (Table 4.3). A higher weed count was always recorded in the plots receiving 400 g N compared to the plots where no N was applied. At first in monocot weed population due to N levels were not significant. The differences in weed population due to N levels were significant at all the sampling dates in the year 1986. At 30 and 60 days, 400 g N exhibited significantly higher weed count than rest of the treatments. However, at 90 and 120 days, 200 g and 400 g N were at par but resulted in significant higher weed count. The minimum population was recorded in plots where no N was applied.

The weed management practices, regardless of N levels, reduced weed population significantly compared to unweeded control. The population was significantly higher under no weeding than other management practices. Black polythene mulch asserted its superiority over other management practices in controlling monocot weeds. Irrespective of N levels, the monocot weed population under different management practices decreased and the management practices followed the order of no weeding, atrazine application, grass mulching, oxyfluorfen and diuron treatment.

For both the years under study the interactions between N levels and weed management practices were found to be non-significant(Appendix-2).

4.1.2.2 Dicot weeds

As with monocot, a direct relationship was observed between N levels and dicot weed population irrespective of weed management practices (Table 4.3). A higher weed count was always recorded in the plots receiving 400 g N compared to the plots where no N was applied. At first and second sampling dates the weed population was significantly affected by N levels. Data reveal that among different levels of N higher weed population was observed with 400 g N and all levels of N differed statistically with each other, however, during 1986 at 60 days, 200 and 400 g N did not exhibit significant difference, in respect of dicot weed population. At 90 and 120 days 200 and 400 g N though at par with each other but were significant from plots where no N was applied.

A perusal of data reveal that mulch materials and herbicides reduced the dicot weed population as compared to unweeded control. Black polythene mulch showed its superiority over other management practices. The differences in dicot weed population due to diuron and oxyfluorfen was not significant with each other at many sampling dates.

The interactions between N levels and management practices at all sampling dates were recorded non-significant during both the years of study (Appendix-3).

4.1.3 Dry weight of weeds

Data pertaining to dry weight of weeds and removal of macronutrient by weeds after 120 days of herbicidal application are presented in Table 4.4.

In general, N application resulted increase in dry weight of weeds irrespective of weed management practices, although the differences between 200 and 400 g N were

Table 4.3: Effect of nitrogen and weed management practices on dicot weed population(m^{-2})

Rreatment		Days after application							
		1985				1986			
		30	60	90	120	30	60	90	120
Nitrogen(g $tree^{-1}$)									
0	(N_0)	3.4 (7.6)	4.2 (15.2)	4.6 (20.0)	8.2 (70.0)	3.4 (10.8)	4.6 (10.8)	5.6 (34.4)	7.8 (61.6)
200	(N_1)	4.0 (13.6)	4.8 (20.8)	5.2 (25.6)	8.9 (78.5)	4.4 (20.0)	5.4 (29.4)	6.4 (43.2)	8.6 (73.6)
400	(N_2)	4.8 (20.8)	5.8 (29.6)	5.6 (30.8)	9.4 (92.8)	5.0 (24.4)	6.0 (34.8)	6.6 (44.8)	8.8 (78.0)
LSD (0.05)		0.5	0.3	0.6	0.5	0.4	0.6	0.4	0.4
Weed management practices									
Unweeded control	(M_0)	5.6 (29.6)	7.0 (46.8)	7.2 (52.0)	11.6 (137.6)	6.8 (62.8)	8.0 (62.8)	9.4 (86.8)	11.6 (131.2)
Atrazine	(M_1)	4.4 (18.0)	5.4 (25.6)	5.6 (29.2)	9.6 (98.8)	5.8 (32.0)	7.0 (48.4)	8.8 (76.0)	9.2 (82.8)
Oxyfluorfen	(M_2)	4.0 (16.0)	4.4 (16.8)	4.6 (19.6)	8.0 (63.2)	3.6 (10.8)	4.0 (14.8)	4.6 (18.8)	7.6 (58.4)
Diuron	(M_3)	3.8 (10.8)	4.2 (14.4)	4.4 (16.8)	7.8 (52.4)	3.6 (9.2)	4.2 (13.6)	4.4 (17.6)	7.4 (50.0)
Grass mulch	(M_4)	3.4 (9.0)	4.2 (16.0)	5.0 (24.6)	8.2 (71.2)	3.4 (8.8)	4.8 (22.8)	5.8 (32.4)	8.4 (68.8)
Polythene mulch	(M_5)	3.0 (8.2)	3.8 (9.0)	4.2 (14.0)	6.6 (43.6)	2.6 (5.0)	3.6 (9.6)	4.2 (15.8)	6.2 (36.2)
LSD (0.05)		0.3	0.1	0.6	1.0	0.5	0.5	0.2	0.4

Note: figures in parentheses are original values, $\sqrt{n+1}$ transformation followed for statistical analysis non-significant for both the years.

The weed management practices significantly reduced the dry weight of weeds in comparison to unweeded control during both the years of study. Compared to other management practices, black polythene mulch proved most efficient in curbing the dry weight, whereas diuron, grass mulch and oxyfluorfen though at par with each other reduced the dry weight of weeds significantly compared to unweeded control.

Study of interactions between N levels and weed management practices reveal that dry weight of weeds was significantly influenced by different treatment combinations. The minimum dry weight was recorded in N_0M_5, but were statistically at par with N_0M_2, N_0M_3, N_0M_4, N_1M_5 and N_2M_5 (Fig.1 and Appendix-4).

4.1.4 Macronutrient removal by weeds

A perusal of the data (Table 4.4) reveal that the removal of macronutrient by weeds increased with the increase in N level. The differences in nutrient removal were significant due to N levels during both the years. The highest removal of all macronutrient was recorded with 400 g N. The weed management practices showed variable removal of macronutrient by weeds. All management practices exhibited significant influence on nutrient removal by weeds compared to unweeded control during both the years. The maximum removal recorded in unweeded control followed by atrazine. Black polythene mulch proved superior in minimising the removal of N,P,K,Ca and Mg by weeds in comparison to grass mulch and herbicidal application.

The interaction between N x M showed significant differences for N,P,K,Ca and Mg removal by weeds. The combination N_2M_0 exhibited highest and N_0M_5 least removal of these nutrients. Besides, the combination N_0M_2, N_0M_3, N_0M_4 and N_0M_5 were also promising in showing less uptake of N by weeds(Fig. 2,3,4 and Appendix-4). The combinations N_0M_3, N_0M_5 and N_2M_5 though recorded significant differences among each other were also effective in less removal of P whereas N_1M_5 and N_0M_3 combinations were more effective in less removal of K and N_1M_3 combination gave prominent effect in checking Ca and Mg removal by weeds.

4.2 Tree productivity

The effect of N and weed management practices on trunk girth, shoot growth and yield are presented in Table 4.5.

4.2.1 Trunk girth

The N as well as different weed management practices influenced trunk girth markedly. The highest increase was recorded in trees receiving 400 g N, however, no significant differences could be observed between 200 and 400 g N.

Table 4.4: Effect of nitrogen and weed management practices on dry weight of weeds(g m^{-2}) and nutrient removal by weeds(kg^{-1})

Treatment		Dry wt of weeds		Nutrient removal by weeds									
				N		P		K		Ca		Mg	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g $tree^{-1}$)													
0	(N_0)	11.7 (143.3)	10.5 (116.0)	16.9	9.2	3.5	1.7	34.6	12.3	4.1	2.6	3.6	3.1
200	(N_1)	13.4 (188.8)	12.1 (162.3)	33.8	23.9	4.9	3.4	45.8	21.9	6.8	5.0	5.1	4.1
400	(N_2)	13.7 (190.7)	12.3 (157.1)	36.6	25.6	5.9	4.3	52.6	26.7	10.5	8.5	7.2	6.2
LSD(0.05)		1.6	0.9	2.2	1.4	0.6	0.5	2.9	1.5	0.5	0.6	0.9	0.3
Weed management practices													
Unweeded control	(M_0)	19.8 (400.2)	18.3 (350.2)	47.3	38.3	8.5	5.3	76.7	58.1	13.1	10.4	10.1	8.2
Atrazine	(M_1)	14.6 (215.8)	11.8 (141.6)	43.9	32.4	6.3	4.1	51.3	18.6	8.0	6.2	6.2	4.9
Oxyfluorfen	(M_2)	11.2 (129.1)	10.5 (111.8)	26.3	14.1	4.5	2.8	44.9	12.1	5.5	4.1	4.7	3.9
Diuron	(M_3)	11.0 (120.4)	9.8 (95.8)	18.8	10.2	3.1	2.0	27.0	10.7	4.3	2.9	3.3	3.2
Grass mulch	(M_4)	11.1 (122.7)	10.9 (121.2)	24.6	14.6	4.0	3.5	34.5	16.3	8.4	6.8	5.4	4.3
Polythene mulch	(M_5)	9.9 (97.7)	8.5 (72.5)	13.9	8.0	2.1	1.2	21.6	6.0	3.3	1.6	2.0	2.2
LSD(0.05)		1.2	1.3	1.7	1.7	0.7	0.1	3.2	1.9	1.1	0.6	0.2	0.3

Note: figures in parenthesis are original values, $\sqrt{n+1}$ transformation followed for statistical analysis

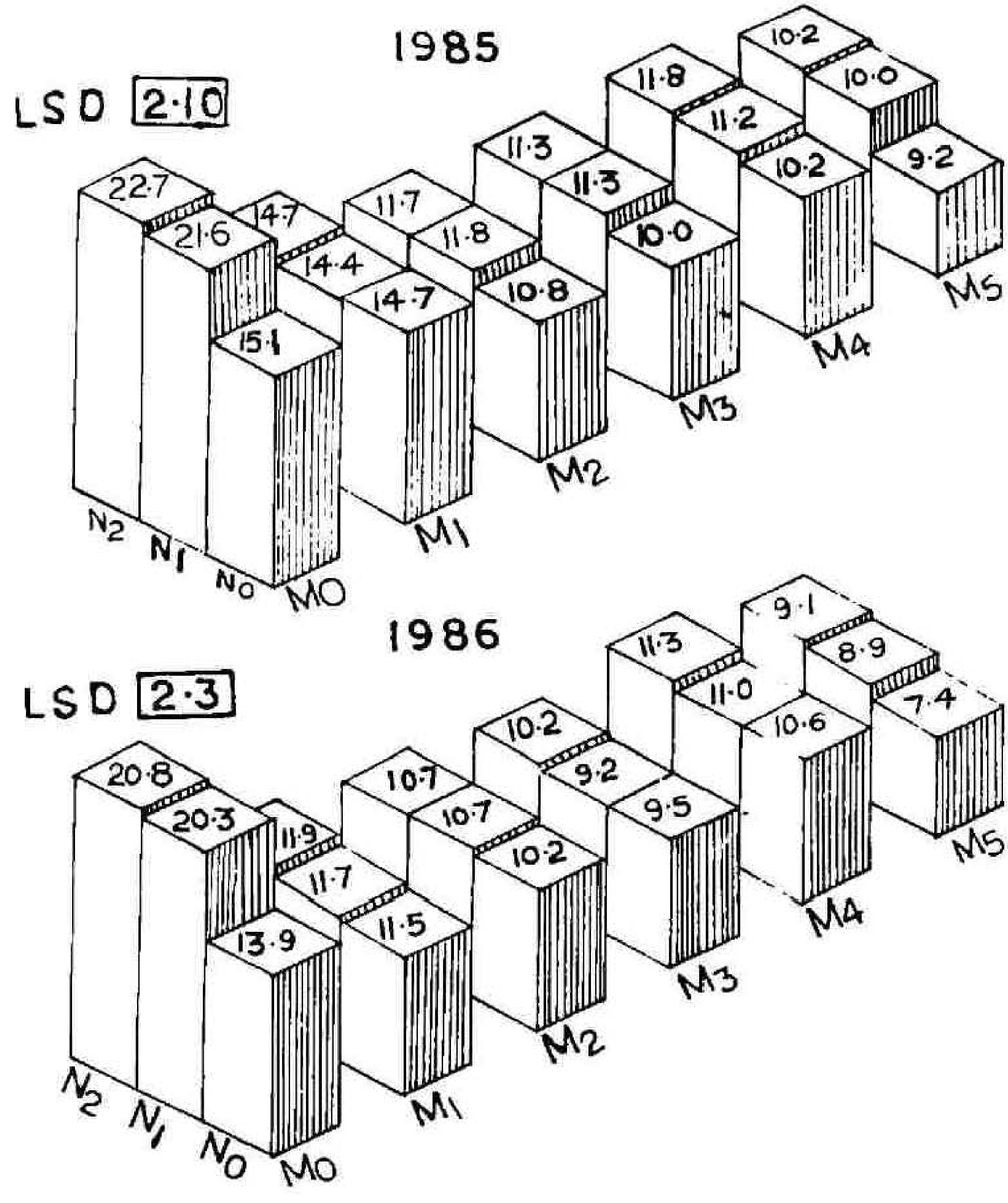


FIG. 1 - EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON DRY WEIGHT OF WEEDS ($g\,m^{-2}$)

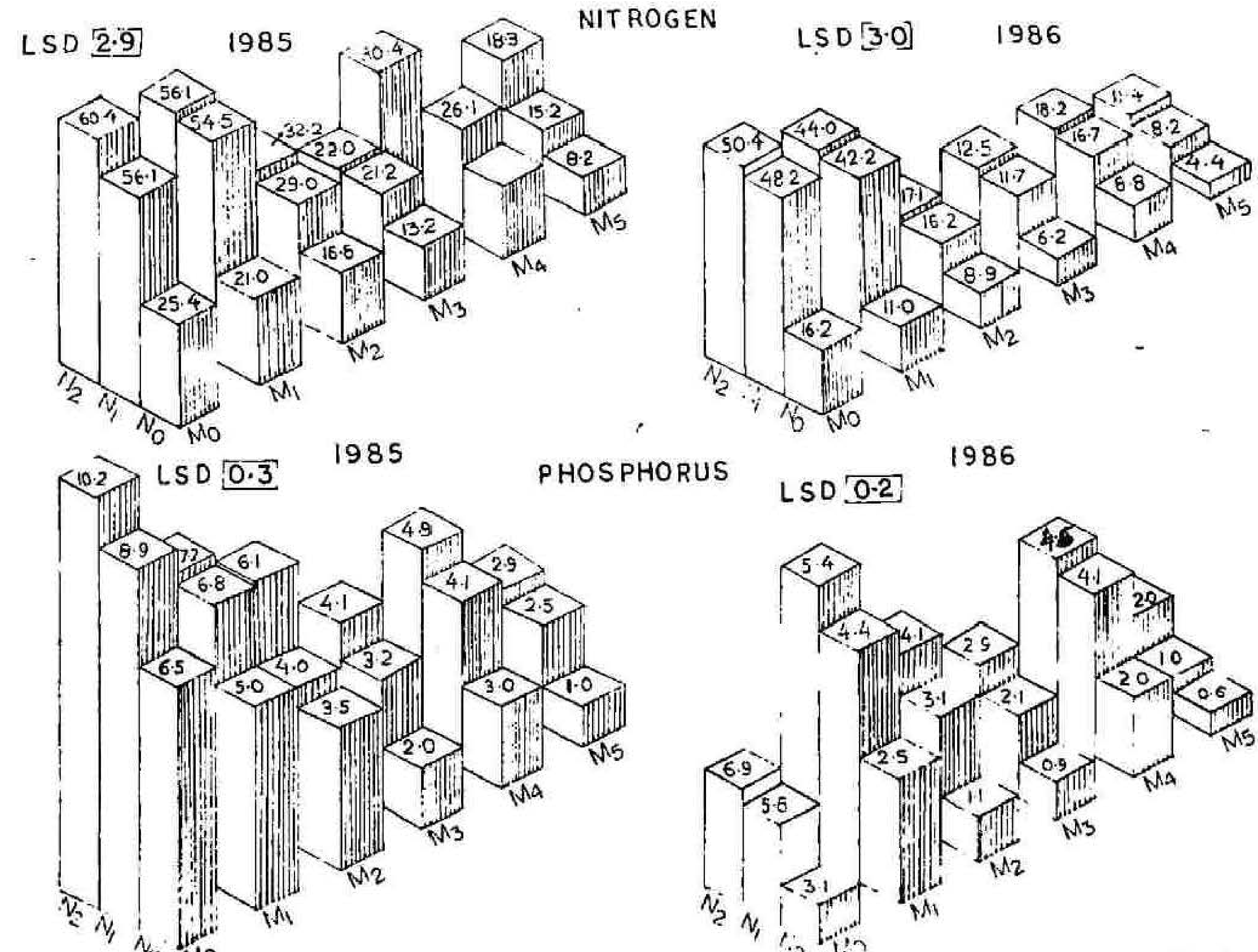


FIG. 2.-EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON N AND P REMOVAL BY WEEDS (kg ha^{-1})

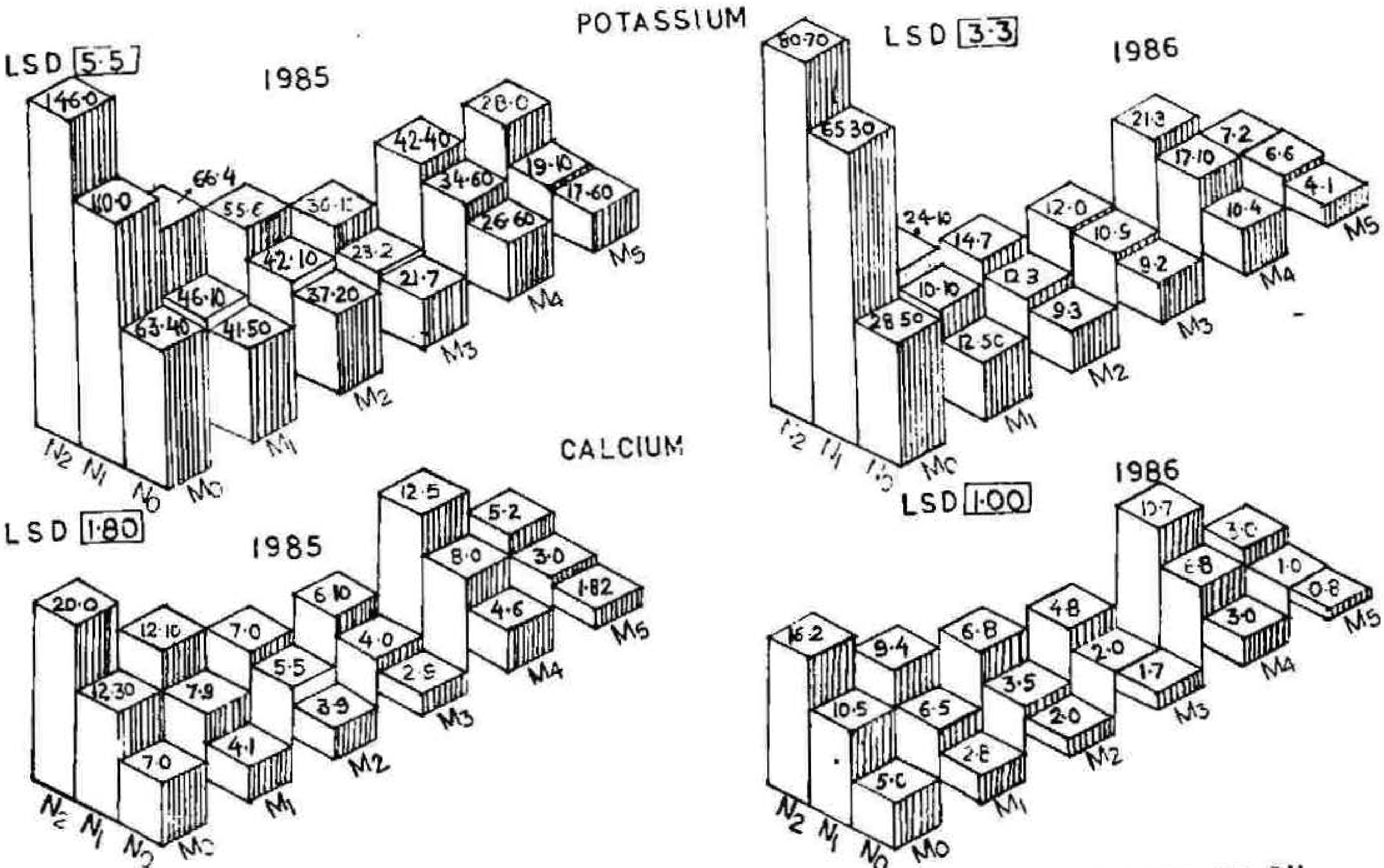


FIG. 3 - EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON K AND Ca REMOVAL BY WEEDS ($Kg\ ha^{-1}$)

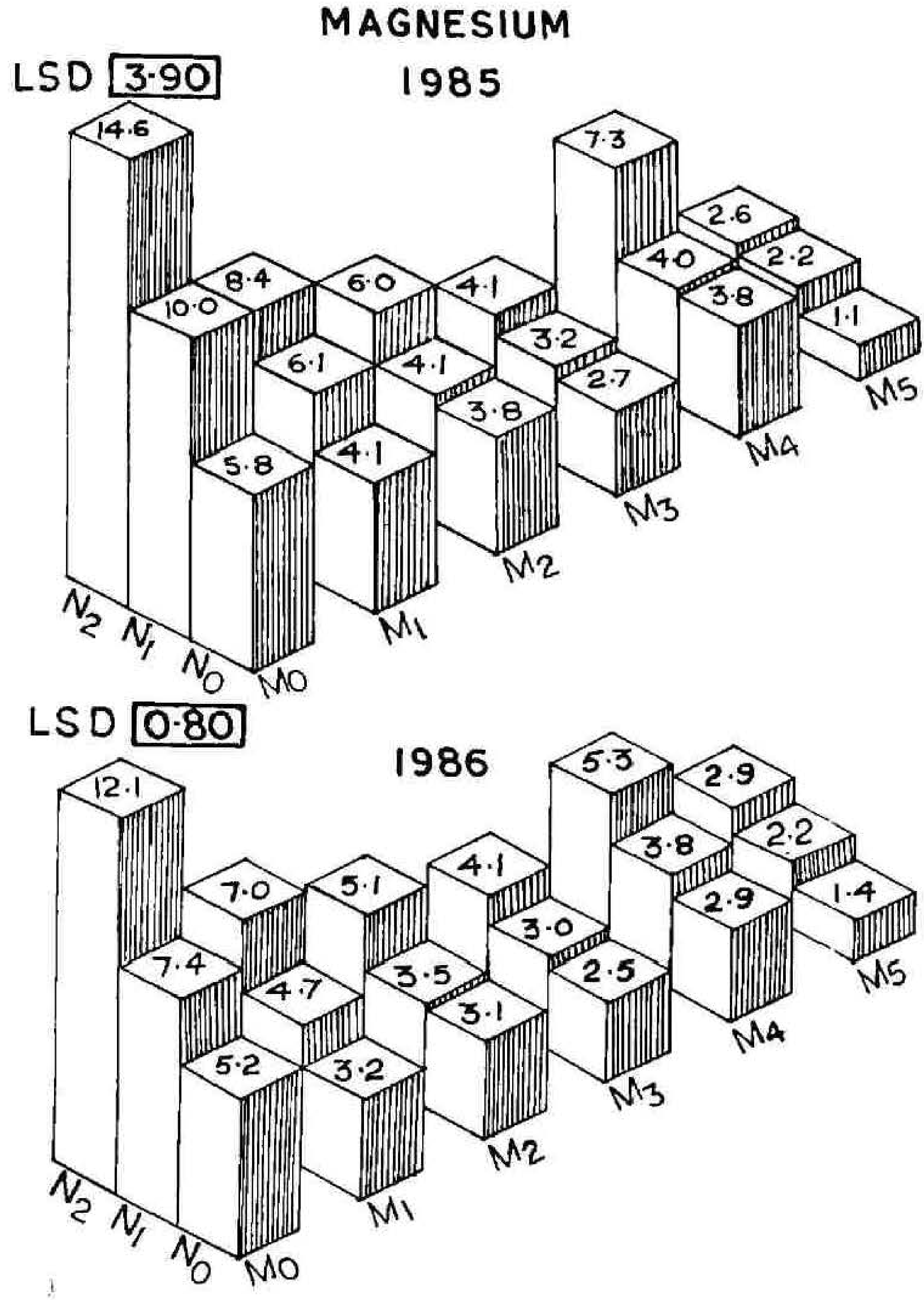


FIG. 4 - EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON Mg REMOVAL BY WEEDS (kg ha^{-1})

Regardless of N treatments, the various soil management practices did not influence the trunk girth of trees during the both years of study. The interactions between N levels and weed management practices on trunk girth were also observed to be non-significant. However, the maximum girth (54.3 and 55.0 cm in 1985 and 1986, respectively) was observed under grass mulching with 400 g N (Appendix-5).

4.2.2 Extension growth

Regardless of soil management practices, a linear relationship was observed to exist between N and extension growth for both years. The shoot growth of trees receiving highest dose of N was 15.7 and 21.0 cm in 1985 and 1986, respectively which differed significantly with rest of the N levels.

The management practices had a differential impact on extension growth. The extension growth was significantly higher under diuron treatment as compared to other management practices during both the years of study. The differences among other management practices were observed to be non-significant in the year 1985. In 1986, all the three herbicidal treatments induced significantly higher extension growth as compared to unweeded control. In both the years, lowest extension growth was observed under no weeding.

The interactions between N x M on extension growth were non-significant (Appendix-5). However, the highest extension growth (18.2 and 24.8 cm) was recorded in trees receiving highest dose of N coupled with diuron (N_2M_3).

4.2.3 Pruning weight

As with other growth parameters, pruning weight was also influenced markedly by different levels of N. No statistical differences were observed between 200 and 400 g N. Among the management practices, grass mulch and diuron application though at par with each other produced significantly higher pruning compared to other management practices.

The interactions between levels of N and management practices were not significant (Appendix-5). However, maximum pruning weight was recorded with N_2M_3 treatment during both the years of study.

4.2.4 Yield

The application of N, regardless of management practices, increased the yield significantly. The highest yield was observed in trees receiving highest level of N for both years. However, the differences in yield between 200 and 400 g N were observed to be non-significant in 1986. The management practices influenced the yield significantly. The highest yield(39.9 kg) during 1985, was recorded in diuron treated plot which was statistically at par with grass mulching. Similarly during 1986, diuron application registered highest yield but the influence of diuron and oxyfluorfen was of similar magnitude.

The differences in fruit yield between black polythene mulch and unweeded control were not significant for both the years.

The interactions between N levels and management practices on yield were not significant. However, the highest yield was obtained from N_2M_3 plot during both the years of study.

4.3 Fruit attributes

The data on fruit weight, size, firmness, TSS, acidity, total sugars, reducing sugars are given in Table 4.6 and 4.7.

4.3.1 Fruit weight

Different doses of N significantly influenced fruit weight during both the years. 400 g N produced heavy fruits than the plots where no nitrogen was applied. The differences between 200 and 400 g N were observed to be non-significant.

Irrespective of N, management practices significantly increased the fruit weight during 1985, however, the effects were not significant during 1986. Polythene mulch proved significantly more effective in increasing fruit weight during 1985 than other management practices. The differences among oxyfluorfen, diuron and grass mulching were observed to be non-significant.

The interactions between levels of N and management practices in respect of fruit weight were significant

Table 4.5: Effect of nitrogen and weed management practices on trunk girth, extension growth, pruning, weight and yield of peach trees

Treatment		Trunk girth (cm)		Shoot growth (cm)		Pruning wt (kg)		Yield (kg)	
		1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})									
0	(N_0)	39.6	40.9	9.9	11.5	1.2	2.6	27.9	26.8
200	(N_1)	45.7	48.7	14.4	19.3	2.0	2.8	38.5	31.8
400	(N_2)	49.7	50.8	15.7	21.0	2.2	3.0	40.5	33.0
LSD (0.05)		5.1	5.2	0.8	1.2	0.3	0.3	1.8	2.7
Weed management practices									
Unweeded control	(M_0)	44.0	45.3	12.6	15.4	1.3	2.3	31.9	27.4
Atrazine	(M_1)	44.2	45.8	13.1	17.3	1.5	2.4	36.0	29.6
Oxyfluorfen	(M_2)	43.2	45.8	13.3	17.9	1.9	2.8	35.8	34.9
Diuron	(M_3)	45.1	46.5	15.2	20.1	2.2	3.1	39.8	35.1
Grass mulch	(M_4)	48.2	50.4	13.1	16.0	2.3	3.2	38.3	30.3
Polythene mulch	(M_5)	46.0	47.0	13.0	16.9	1.6	2.8	32.0	29.9
LSD (0.05)		NS	NS	0.9	1.5	0.2	0.2	2.6	2.8

(Fig.5 and Appendix-6). During 1985 the treatment N_2M_5 showed superiority in increasing fruit weight over all other treatments except N_1M_5. In the following year, the the treatment combinations N_0M_1, N_0M_4 and N_0M_5 though at par with each other resulted in significant increase in fruit weight.

4.3.2 Fruit size

A perusal of the data reveal that the fruit size was not influenced by different levels of N during 1985, but in second year increase in fruit size was recorded with increase in levels of N. The differences in fruit size due to 0 and 200, 200 and 400 g N were not discernible.

As with N, the effect of management practices on fruit size was significant only in the second year of study. The highest fruit size(25.7 cm) was recorded under grass mulching. However, no significant differences could be recorded among grass mulch, polythene mulch, atrazine and unweeded control. The herbicides oxyfluorfen and diuron resulted in decrease in fruit size compared to unweeded control.

The interactions due to N levels and management practices in respect of fruit size were observed to be non-significant (Appendix-6).

4.3.3 Firmness

Data presented in Table 4.7 reveal that in 1985, it decreased significantly with increase in N levels.

Table 4.6: Effect of nitrogen and weed management practices on weight and size of fruit

Treatment		Fruit weight (g)		Fruit size (cm)	
		1985	1986	1985	1986
Nitrogen (g tree^{-1})					
0	(N_0)	57.7	51.6	21.2	22.3
200	(N_1)	62.6	55.0	22.1	23.5
400	(N_2)	64.9	56.3	22.5	24.7
LSD(0.05)		2.7	3.2	NS	1.6
Weed management practices					
Unweeded control	(M_0)	57.8	42.2	21.4	24.7
Atrazine	(M_1)	58.8	45.4	22.3	23.3
Oxyfluorfen	(M_2)	60.6	46.5	22.0	21.5
Diuron	(M_3)	61.5	46.9	20.9	21.2
Grass mulch	(M_4)	60.7	49.1	22.6	25.7
Polythene mulch	(M_5)	70.8	47.7	22.7	24.8
LSD(0.05)		1.2	NS	NS	1.4

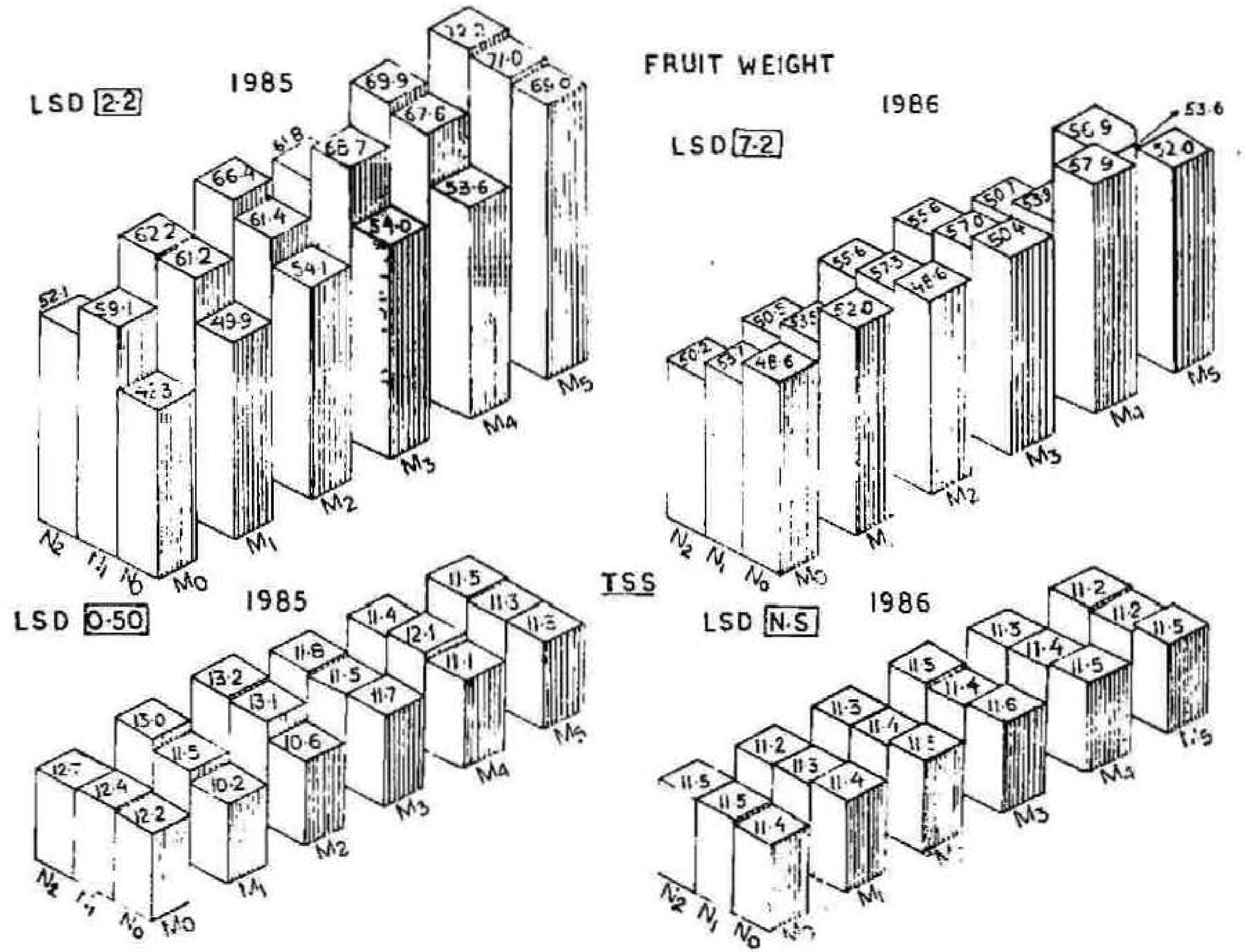


FIG. 5 EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON FRUIT WEIGHT (g) AND TSS (%)

The different levels of N failed to show significant influence on fruit firmness in 1986.

As with N, the management practices influenced the fruit firmness only during 1985. The grass mulching and unweeded control though produced fruit of same firmness yet recorded maximum firmness and were at par with other management practices except polythene mulch.

The interactions between N levels and management practices in respect of fruit firmness were observed to be non-significant during both the years of study(Appendix-7).

4.3.4 Total soluble solids(TSS)

Data given in Table 4.7 reveal that during both the years N doses exercised non-significant influence on TSS of fruits. However, the TSS decreased with increase in N levels.

The effect of management practices on fruit TSS was observed to be significant only in 1985. The highest TSS (12.4%) was recorded in unweeded control due to grass mulch diuron and atrazine were not significant. The polythene mulch though at par with atrazine resulted in decrease in TSS content significantly compared to other management practices.

In 1985, the interactions between N levels and management practices were significant(Fig.5 and Appendix-7). The treatment N_2M_2 produced a significant increase in TSS compared to rest of the treatment combinations. No significant differences among N_1M_1, N_2M_1 and N_2M_2 treatment combinations were observed. The minimum TSS(12.2 %) was recorded in N_0M_1 treatment.

4.3.5 Acidity

In 1985, significant increase in per cent acidity was observed with increase in N levels upto 200 g, whereas 400 g N application resulted in a significant decrease compared to other levels of N. In 1986, the differences due to different levels were observed to be non-significant. All the management practices except grass mulching increased the acidity of fruit significantly compared to unweeded control in 1985. In the subsequent year, the different management practices failed to show any significant influence on the acidity of fruit. The interactions between N levels and management practices were observed to be non-significant during both the years.

4.3.6 Total sugars

The total sugars were not affected due to N levels for both the years. The management practices had a differential impact on per cent total sugars. The unweeded control produced fruits with highest total sugars which did not differ statistically from oxyfluorfen treated plots. The treatments oxyfluorfen, diuron ,grass and polythene mulch were observed to be statistically at par.

The interactions between N levels and management practices were significant during both the years(Fig.6 and Appendix-7). In 1985, the treatment N_1M_0 improved sugar contents significantly compared to rest of the treatment combinations. The treatment N_1M_4 though at par with N_0M_4, N_1M_4, N_2M_3 and N_2M_5 yet significantly decreased the total sugars. In the second year, treatment N_0M_3 significantly improved the total sugar contents (10.5%) than all other treatments but was observed at par with N_0M_2, N_0M_4, N_1M_1, N_1M_2, N_1M_3, N_1M_5 and N_2M_2.

4.3.7 Reducing sugars

For both the years in general, a decrease in the reducing sugars was observed with the increase in the level of N. Trees receiving 200 and 400 g N were at par in affecting the reducing sugar contents.

The reducing sugars of fruit were not affected significantly by different management practices in 1985. However, during the year 1986, polythene mulching and oxyfluorfen though at par with each other exhibited the minimum (5.8 %) reducing sugars. The results of atrazine and grass mulch were at par with the unweeded control. The interactions between N levels and weed management practices were non-significant for both the years.

Table 4.7: Effect of nitrogen and weed management practices on physicol-chemical characteristics of fruit

Treatment		Firmness (%)		TSS (%)		Acidity (%)		Total sugars (%)		Reducing sugars (%)	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})											
0	(N_0)	4.5	4.1	12.2	11.5	0.65	0.63	8.3	9.4	4.6	5.7
200	(N_1)	4.4	4.0	12.0	11.4	0.67	0.64	8.3	9.2	4.5	5.5
400	(N_2)	4.2	4.0	11.5	11.3	0.62	0.61	61.5	9.4	4.4	5.4
LSD (0.05)		0.1	NS	NS	NS	0.03	NS	NS	NS	0.1	0.2
Weed management practices											
Unweeded control	(M_0)	4.5	4.5	12.4	11.5	0.59	0.62	8.9	9.5	4.2	5.3
Atrazine	(M_1)	4.3	4.0	11.5	11.3	0.67	0.65	7.6	9.7	4.7	5.7
Oxyfluorfen	(M_2)	4.3	3.9	12.0	11.5	0.65	0.64	8.6	9.8	4.7	5.8
Diuron	(M_3)	4.4	3.9	11.7	11.4	0.64	0.62	8.2	9.7	4.4	5.4
Grass mulch	(M_4)	4.5	4.0	11.6	11.3	0.62	0.61	8.2	8.9	4.5	5.6
Polythene mulch	(M_5)	4.2	3.8	11.4	11.3	0.63	0.60	8.2	9.0	4.4	5.8

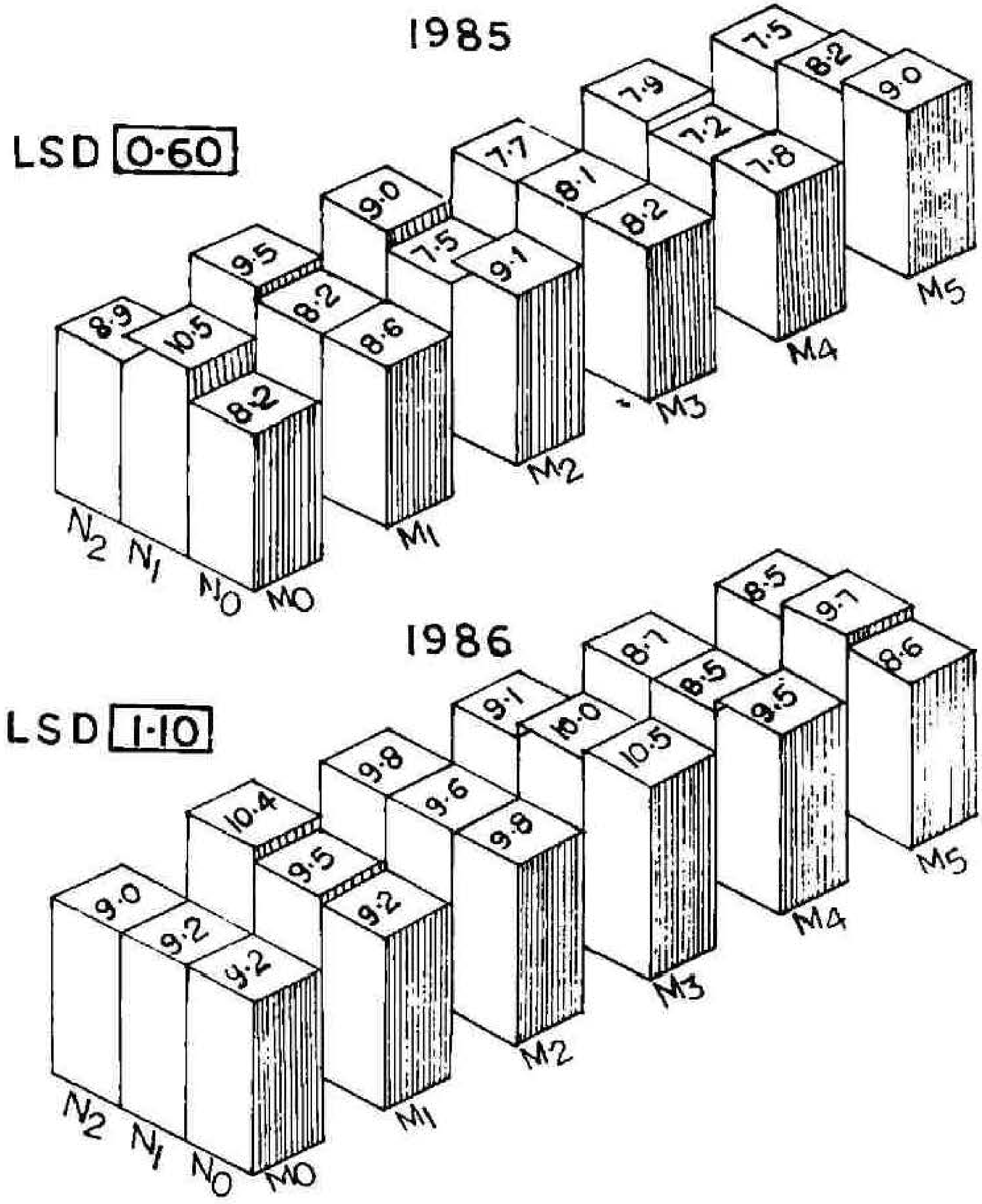


FIG. 6–EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON TOTAL SUGAR CONTENT OF FRUIT(%)

4.4 Leaf nutrient status

The data regarding leaf nutrient status as influenced by N and management practices during 1985 and 1986 are presented in Table 4.8.

4.4.1 Macronutrient

4.4.1.1 Nitrogen

Nitrogen application, irrespective of management practices improved leaf N content significantly during both the years. With increment in the N doses, leaf N content improved proportionately in 1985. However, no significant differences were observed between 200 and 400 g N during 1986.

The effect of management practices was significant only in the year 1986. The grass mulching produced significantly higher leaf N content than other management practices. All the herbicides treatments and polythene mulch produced significantly higher leaf N content than unweeded control, although the differences with each others were not significant.

The interactions between N and used management practices revealed that grass mulching with 400 g N resulted in the highest leaf N content(Fig.7 and Appendix-8).

4.4.1.2 Phosphorus

The effect of N levels on leaf P content was not significant during both the years of study. In the year

1985, the management practices had a significant influence on the leaf P concentration. The highest P content was recorded in atrazine treated plots but the differences among atrazine, grass and polythene mulch were not significant. Unweeded control resulted in lower leaf P content than other management practices. The interactions due to N and weed management practices on leaf P were non-significant(Appendix-8).

4.4.1.3 Potassium

Graded level of N resulted in uecreased leaf K content although the differences between 200 and 400 g N were not sign ificant during both the years of study. But in the year 1986, the difference between 0 and 200 g N was also not significant.

It is evident from the data that grass mulching and diuron treatment resulted in significantly higher leaf K content than other management practices. The difference between polythene mulch and unweeded control was not significant for both the years.

The interactions between N and management practices were significant in respect of leaf K content(Fig.7 and Appendix-8). The maximum foliar K content was recorded under grass mulch when no nitrogen was applied. In general, different management practices under different levels of N resulted in higher K content.

4.4.1.4 Calcium

The application of N resulted in significant decrease in foliar Ca content during both the years of study. The differences among three levels of N were observed to be significant.

During both the years of study, all the weed management practices except polythene mulching improved the leaf Ca content significantly than unweeded control. Grass mulching resulted in significantly higher leaf Ca, followed by diuron, oxyfluorfen, atrazine, unweeded control and polythene mulching.

The interactions between N levels and management practices in respect of leaf Ca content were observed to be significant during both the years(Fig.8 and Appendix-8). The treatment N_0M_4 and N_2M_4 resulted in significantly higher leaf Ca than rest of the treatment combinations.

4.4.1.5 Magnesium

The different levels of N decreased the leaf Mg significantly in 1985. But in the following year, 200 g N raised the leaf Mg content significantly. Thereafter, a decrease in leaf Mg was noticed.

The weed management practices improved the leaf Mg content significantly. Grass mulching resulted in significantly higher leaf Mg content during both the years of study, although the difference between grass mulching and diuron was not significant. Leaf Mg content

Table 4.8: Effect of nitrogen and weed management practices on macronutrient status of leaf (% dry weight)

Treatment		N		P		K		Ca		Mg	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen (g $tree^{-1}$)											
0	(N_0)	2.28	2.25	0.19	0.20	1.58	1.57	2.12	2.16	0.65	0.63
200	(N_1)	3.01	3.14	0.18	0.20	1.50	1.54	2.01	2.08	0.62	0.65
400	(N_2)	3.16	3.15	0.17	0.19	1.47	1.50	1.91	1.96	0.59	0.61
LSD (0.05)		0.06	0.05	NS	NS	0.07	0.06	0.07	0.02	0.02	0.01
Weed management practices											
Unweeded control	(M_0)	2.67	2.61	0.16	0.18	1.44	1.45	1.81	1.81	0.56	0.53
Atrazine	(M_1)	2.80	2.79	0.20	0.21	1.55	1.57	1.86	2.01	0.62	0.64
Oxyfluorfen	(M_2)	2.88	2.75	0.17	0.20	1.48	1.52	2.12	2.21	0.59	0.61
Diuron	(M_3)	2.97	2.96	0.17	0.20	1.66	1.61	2.18	2.29	0.65	0.67
Grass mulch	(M_4)	3.13	3.20	0.19	0.20	1.66	1.64	2.46	2.49	0.66	0.70
Polythene mulch	(M_5)	2.79	2.79	0.19	0.20	1.45	1.45	1.65	1.71	0.59	0.61
LSD (0.05)		NS	0.055	0.02	NS	0.08	0.01	0.09	0.08	0.02	0.03

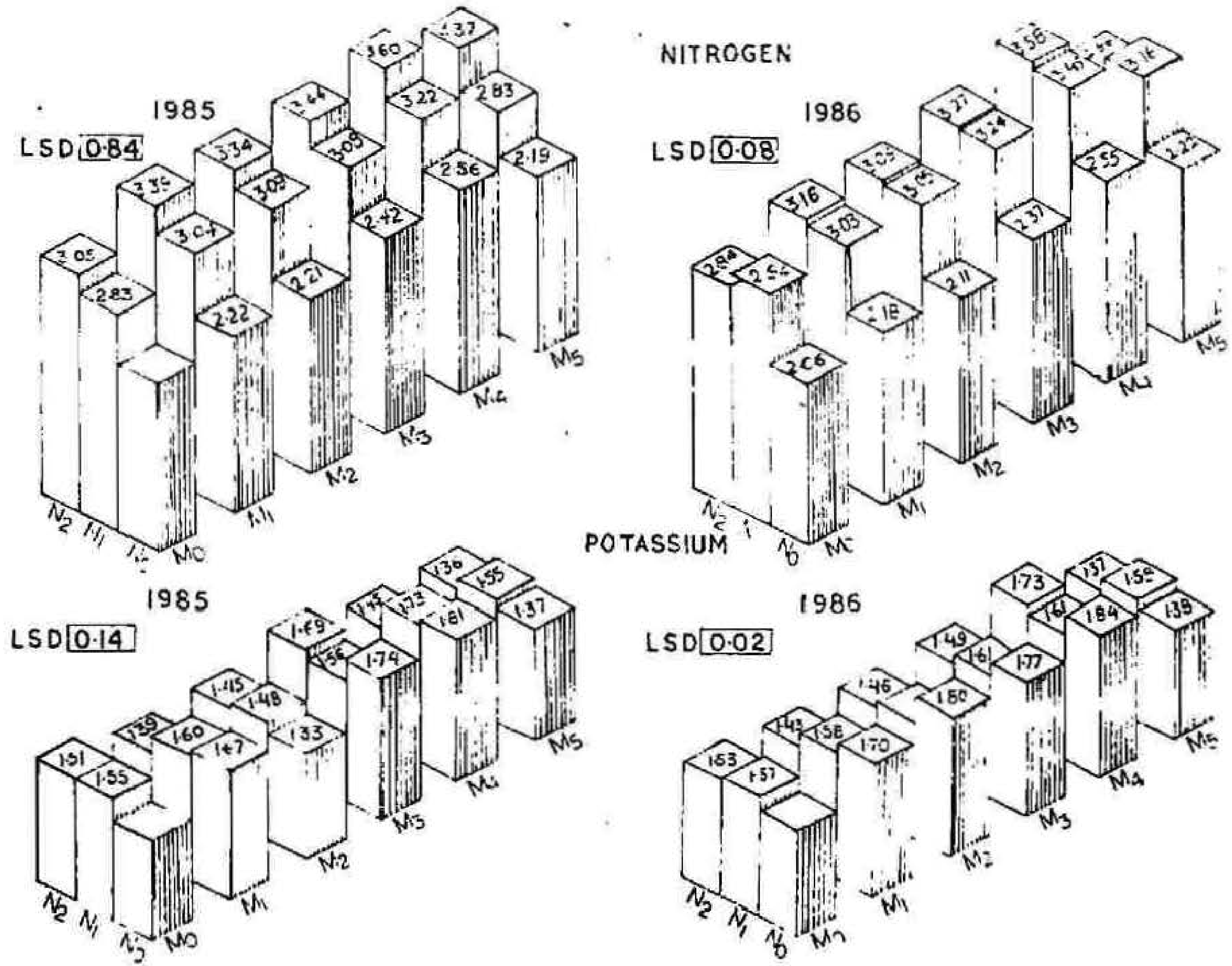


FIG. 7- EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON LEAF N AND K (% dry weight)

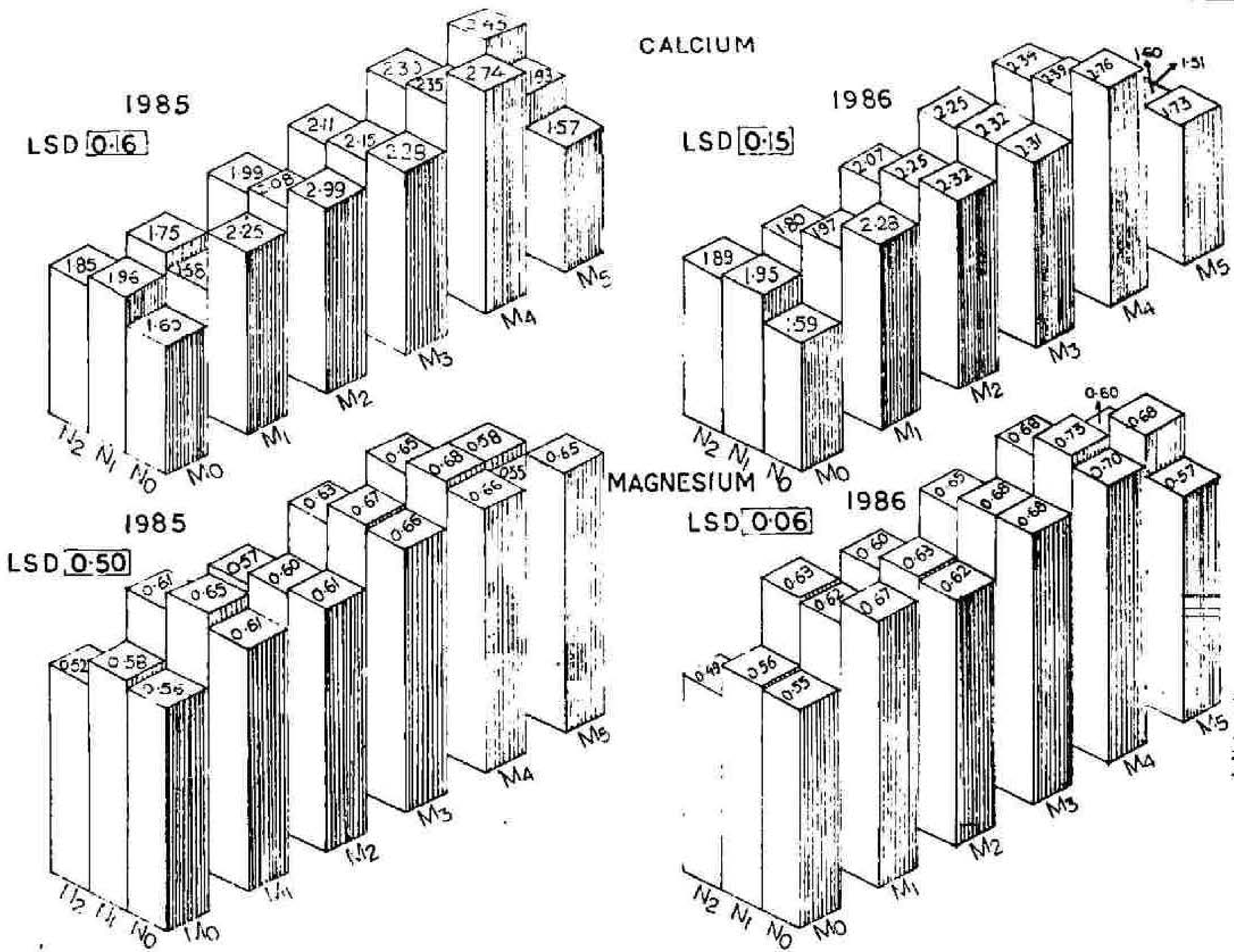


FIG. 8-EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON LEAF Ca AND Mg (% dry weight)

was significantly lower under unweeded control as compared to other management practices.

The interactions between N and management practices in respect of leaf Mg content (Fig.8 and Appendix-8) were observed to be significant. The treatment combination N_1M_4 followed by N_1M_3, N_2M_4, N_0M_3 and N_0M_4 were observed to improve leaf Mg during 1985, whereas during the subsequent year the same combination exhibited highest foliar Mg and was statistically at par with N_0M_4, N_0M_1, N_1M_3, N_1M_5 and N_2M_4. The minimum foliar content was recorded in N_2M_0 treatment during both the years of study.

4.4.2 Micronutrient

4.4.2.1 Iron

Data presented in Table 4.9 reveal that graded levels of N significantly increased the leaf Fe, However, no statistical difference could be observed between 200 and 400 g N. Regardless of N, atrazine application increased the leaf Fe, significantly compared to all other management practices. However, a decrease in leaf Fe content under black polythene mulching was noticed for both the years. The interaction effects due to N and management practices observed to be non-significant(Appendix-9).

4.4.2.2 Manganese

In general, N application resulted an increase in leaf Mn upto 200 g N in the year 1985. In the subsequent year all levels of N resulted an increase in Mn, but the differences between 200 and 400 g N were observed at par. The highest leaf Mn(67.2 ppm) was recorded in plants receiving 200 g N during 1985, while in subsequent year it was recorded in trees receiving 400 g N.

The application of diuron and grass mulch increased leaf Mn while other management practices decreased it. The grass mulch proved suprior in improving the leaf Mn. The interactions due to N and management practices (Appendix-9) reveal that during 1985, grass mulch with 200 g N and in the subsequent year with 400 g N, resulted in the highest leaf Mn.

4.4.2.3 Zinc

A perual of data reveals that graded level of N enhanced leaf Zn. However, the differences between 200 and 400 g N was non-significant. Maximum leaf Zn was recorded in trees receiving 400 g N.

The application of oxyfluorfen proved ineffective in improving leaf Zn. The differences between polythene mulch and unweeded control were observed at par during both the years. In 1986, all the weed management practices except oxyfluorfen and polythene mulch enhanced the leaf Zn content significantly.

The interactions due to N and management practices with respect to leaf Zn were observed to be non-significant (Appendix-9).

Table 4.9: Effect of nitrogen and weed management practices on micronutrient status of leaf (ppm dry weight)

Treatment		Fe 1985	Fe 1986	Mn 1985	Mn 1986	Zn 1985	Zn 1986	Cu 1985	Cu 1986
Nitrogen (g tree^{-1})									
0	(N_0)	170.6	167.0	49.6	51.5	11.5	8.4	5.0	4.5
200	(N_1)	186.6	191.1	67.2	65.5	13.2	14.6	5.3	4.8
400	(N_2)	189.9	193.6	67.0	67.8	14.7	15.9	4.9	4.4
LSD (0.05)		6.9	7.3	3.9	2.9	1.6	1.5	0.2	0.1
Weed management practices									
Unweeded control	(M_0)	180.0	182.0	60.2	61.2	12.5	13.2	5.2	4.5
Atrazine	(M_1)	195.5	196.8	57.8	56.9	13.6	15.3	5.3	4.6
Oxyfluorfen	(M_2)	178.0	189.6	48.3	50.5	12.5	13.6	4.3	3.8
Diuron	(M_3)	184.0	185.5	63.2	66.0	13.1	14.8	5.0	4.5
Grass mulch	(M_4)	184.4	185.9	83.6	75.0	14.8	15.8	6.1	5.6
Polythene mulch	(M_5)	172.5	173.6	53.5	60.1	12.3	13.3	4.5	4.0
LSD (0.05)		7.5	8.5	3.6	3.6	1.4	1.5	0.3	0.3

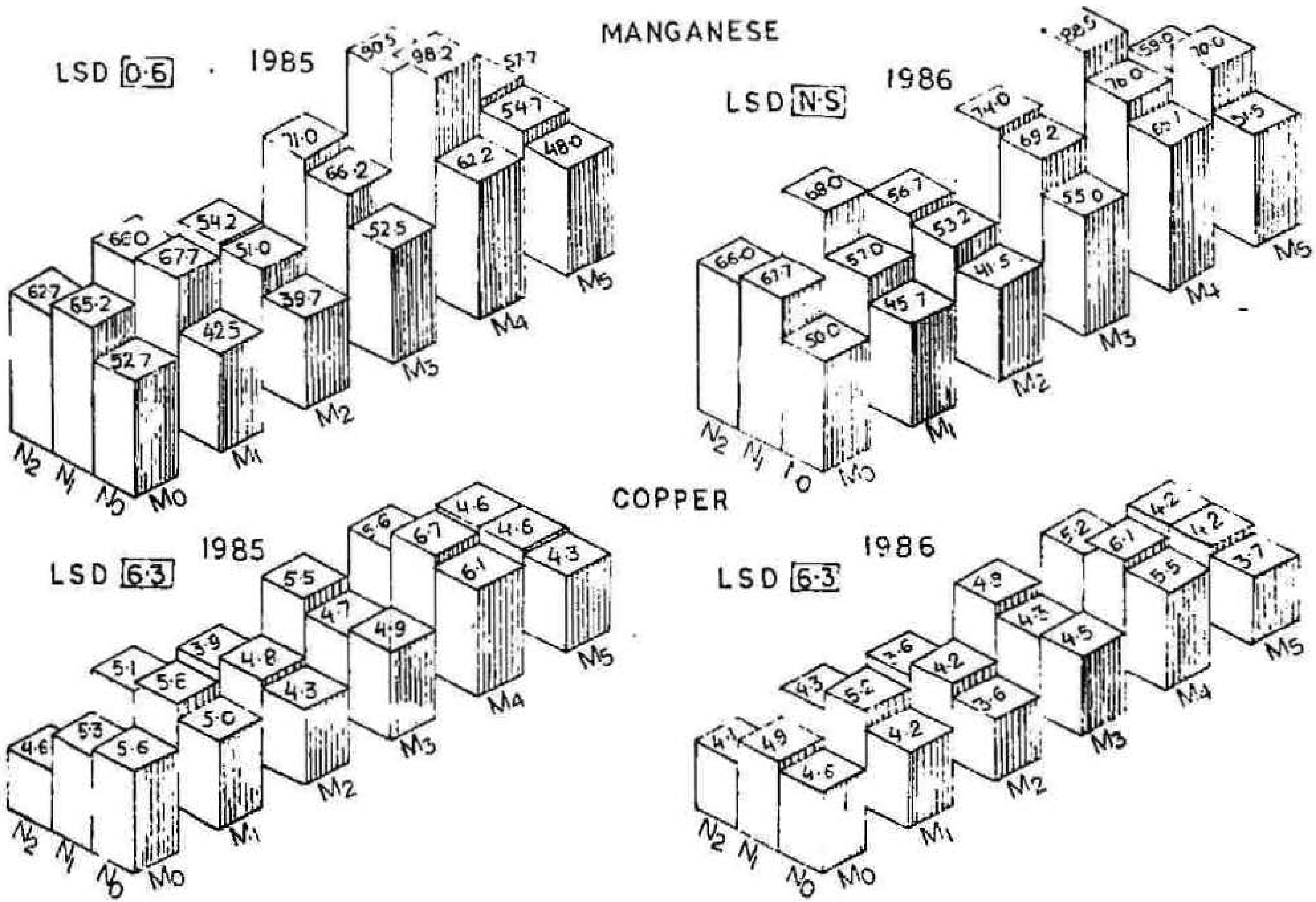


FIG. 9-EFFECT OF INTERACTION BETWEEN N AND WEED MANAGEMENT PRACTICES ON LEAF Mn AND Cu (ppm dry weight)

4.4.2.4. Copper

Among graded levels of N, only 200 g N increased the leaf Cu significantly. A further increase in N rates resulted in an decrease leaf Cu. The minimum leaf Cu was recorded in trees receiving the highest rate of N.

Irrespective of N, the highest leaf Cu was recorded with grass mulch and the lowest in oxyfluorfen treated plots. Application of oxyfluorfen and polythene mulching decreased leaf Cu content compared to unweeded control, while other management practices improved leaf Cu.

The interactions between N and management practices in respect of leaf Cu were observed to be significant only during 1985(Fig.9 and Appendix-9). The treatment cumbination N_1M_4 proved superior in increasing the leaf Cu. The lowest Cu was recorded in N_2M_2.

4.5. Mineral composition of fruit

The data regarding the nutrient status of fruit as influenced by different levels of N and weed management practices are presented in Table 4.10 and 4.11.

4.5.1. Macronutrient

4.5.1.1. Nitrogen

The application of N improved the N content of fruits, however, no significant difference was observed between 0 and 200 g N during both the years of study.

In general, all management practices except polythene mulch increased the N content of fruit compared to unweeded control during both the years. Polythene mulching had a depressing effect on fruit N content than unweeded control in 1985, however, the differences in the following year were observed to be non-significant. The differences among three herbicidal treatments were also observed at par with each other. The fruits under grass mulching had highest N content. The interactions between N x M were significant(Appendix-10).

4.5.1.2 Phosphorus

A perusal of the data reveals that neither the N levels nor the weed management practices influenced fruit Pcontent significantly during both the years. The interactions between N x M were also observed to be significant (Appendix-10).

4.5.1.3 Potassium

Graded levels of N resulted in decreased fruit K, but the differences were found significant only in 1986. Significant differences in fruit K due to [illegible] and 200 g N were recorded, however, the differences between 200 and 400 g N were found to be statistically at par. The highest fruit K was observed where no N was applied.

There was a significant increase in fruit K content under grass mulching during both the years as compared to other management practices. The data also reveal that other management practices except oxyfluorfen improved fruit K significantly compared to unweeded control. The interactions (Appendix-10) between N levels and weed management practices were found non-significant during the course of study.

4.5.1.4 Calcium

The Ca content in fruit decreased with enhanced N rates although the difference between 200 and 400 g N was not significant in the year 1985. For both the years the lowest fruit Ca was recorded with 400 g N.

Except black polythene mulch, all management practices resulted in increase in fruit Ca content. The fruit Ca concentration was higher under grass mulching but it did not differ significantly with atrazine in 1985. But in the following year no significant differences could be recorded among diuron, polythene mulch and unweeded control.

The interactions between N levels and weed management practices were observed significant only in 1986. Statistically maximum fruit Ca content (72.2 mg 100 g^{-1}) was recorded with N_0M_4 closely followed by N_1M_4 and N_0M_1. The treatment N_2M_5 resulted in significantly lower Ca content (45.7 mg 100 g^{-1}) compared to rest of the treatment combinations (Appendix-10).

Table 4.10: Effect of nitrogen and weed management practices on macronutrient status of fruit (mg 100 g^{-1} fresh weight)

Treatment		N		P		K		Ca		Mg	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen (g $tree^{-1}$)											
0	(N_0)	146.8	149.8	22.5	26.0	118.6	113.9	66.0	62.2	25.7	26.3
200	(N_1)	155.7	153.5	22.8	26.4	115.1	106.2	62.5	57.8	26.6	30.2
400	(N_2)	161.2	163.8	22.6	25.4	113.6	102.5	60.2	54.4	27.3	30.7
LSD (0.05)		11.6	5.6	NS	NS	NS	5.1	5.9	2.8	NS	1.3
Weed management practices											
Unweeded control	(M_0)	153.3	154.6	22.5	25.7	96.1	90.3	54.3	52.8	26.0	28.5
Atrazine	(M_1)	154.0	153.1	22.9	25.9	127.8	110.9	69.5	60.8	23.4	28.1
Oxyfluorfen	(M_2)	156.0	153.6	22.5	26.0	98.2	94.6	65.1	58.0	25.5	28.6
Diuron	(M_3)	159.0	159.0	22.8	26.3	113.1	99.0	60.5	50.9	28.0	28.7
Grass mulch	(M_4)	164.9	166.7	23.0	26.3	136.6	154.3	73.8	68.0	32.3	32.7
Polythene mulch	(M_5)	140.2	147.3	22.0	22.5	122.5	117.2	54.2	52.4	24.1	26.6
LSD (0.05)		11.9	9.0	NS	NS	8.9	6.7	7.7	2.6	NS	2.4

4.5.1.5 Magnesium

Effect of N level on fruit Mg content was significant only in 1986. The Mg content in fruit increased with increased N dose, though the difference between 200 and 400 g N was observed to be non-significant. The highest fruit Mg content (30.7 mg 100 g^{-1}) was observed with 400 g N.

As with N, the management practices also showed significant effect in respect of fruit Mg content only in 1986. Grass mulching resulted in significantly higher fruit Mg content compared to other management practices. Polythene mulching though at par with unweeded control exhibited the lowest Mg content.

The interactions due to N levels and management on Mg content of fruit were found to be non-significant (Appendix-10).

4.5.2 Micronutrients

4.5.2.1 Iron

Supplemental N resulted in increased fruit Fe content although the difference between 200 and 400 g N was not significant during both the years.

All the weed management practices except polythene mulch improved the Fe content in both the years of study. Grass mulching, though at par with diuron, was observed superior to other management practices. The difference between oxyfluorfen and diuron was found non-significant during both the years. The interactions between N levels and management practices were observed to be non-significant (Appendix-11).

4.5.2.2 Manganese

Graded levels of N could not bring any significant changes in the fruit Mn content during both the years of study.

The weed management practices did not influence the Mn content of fruits in 1985. In the subsequent year, grass mulching had a marked influence on fruit Mn content as compared to other management practices. Oxyfluorfen resulted in decreased Mn content. No significant differences were recorded among atrazine, diuron and unweeded control treatments. The interactions between N levels and management practices were found to be non-significant(Appendix-11).

4.5.2.3 Zinc

The fruit Zn content increased significantly upto 200 g N, further increase in N reduced it. During 1985, all levels of N differed significantly whereas during 1986, the difference between 200 and 400 g was found to be statistically at par. Lowest Zn content was recorded in plot where no N was applied.

Grass mulch resulted in significantly higher fruit Zn compared to other management practices. Polythene

Table 4.11: Effect of nitrogen and weed management practices on micronutrient status of fruit (mg 100 g^{-1} fresh weight)

Treatment		Fe		Mn		Zn		Cu	
		1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen (g $tree^{-1}$)									
0	(N_0)	0.87	0.83	0.12	0.11	1.38	1.04	0.18	0.15
200	(N_1)	0.92	0.89	0.14	0.11	2.14	1.17	0.19	0.14
400	(N_2)	0.94	0.92	0.15	0.12	1.63	1.10	0.18	0.14
LSD (0.05)		0.05	0.04	NS	NS	0.14	0.10	NS	NS
Weed management practices									
Unweeded control	(M_0)	0.84	0.83	0.13	0.11	1.81	1.17	0.19	0.15
Atrazine	(M_1)	0.91	0.86	0.13	0.11	1.61	1.05	0.18	0.14
Oxyfluorfen	(M_2)	0.94	0.89	0.14	0.09	1.69	1.08	0.18	0.14
Diuron	(M_3)	0.95	0.92	0.14	0.10	1.72	1.12	0.19	0.13
Grass mulch	(M_4)	0.96	0.94	0.15	0.14	1.95	1.22	0.21	0.18
Polythene mulch	(M_5)	0.85	0.83	0.13	0.11	1.52	0.98	0.16	0.12
LSD (0.05)		0.10	0.04	NS	0.02	0.12	0.13	0.03	0.02

mulching exhibited the minimum Zn content and it was at par with atrazine during both the years. The interactions (Appendix-11) due to N levels and weed management practices were observed to be non-significant for both the years.

4.5.2.4 Copper

Cu content in fruit was not affected by graded levels of N during both the years. However, the weed management practices had differential effect on fruit Cu content. In 1985, grass mulching though at par with diuron resulted in significantly higher fruit Cu content in comparison to other management practices. Almost similar trend was noticed in 1986 but the differences among atrazine, oxyfluorfen and unweeded control were not significant. For both the years polythene mulching reduced the fruit Cu content significantly as compared to unweeded control. The interaction due to N levels and management practices were not significant (Appendix-11).

4.6 Soil properties

Data pertaining to the effect of N and weed management practices on soil pH, electrical conductivity and organic carbon are presented in Table 4.12.

4.6.1 Soil pH

Data presented in Table 4.12 reveal that all the N levels reduced soil pH significantly during both the years. The minimum soil pH was recorded in plots receiving highest dose of N. The herbicides in general decreased the soil pH compared to other management practices, however, the difference between oxyfluorfen and polythene mulch was not significant in the year 1985. In the subsequent year the differences among black polythene, grass mulch and unweeded control were not significant. Soil pH varied greatly with depth. The pH at the surface (0-15 cm) was lower as compared to other two lower depths.

Interaction effects

The year-wise data regarding the interaction effects on N x M, N x D, M x D and N x M x D for soil pH are presented in Appendix-12 and 13.

N x M interaction

The treatment combination N_2M_3 decreased the soil pH significantly than rest of the combinations in 1985. The maximum soil pH was recorded in N_0M_0 treatment and it was statistically at par with N_0M_1 and N_0M_2 treatments. The treatment N_2M_4 though at par with N_2M_1 decreased the soil pH significantly compared to other treatment combinations. No statistical changes in soil pH due to N and management practices were recorded in 1986 (Fig.10 and Appendix-12).

N x D interaction

The interactions between N x D on soil pH were observed to be non-significant during both the years (Appendix-12).

Table 4.12: Effect of nitrogen and weed management practices on soil pH, electrical conductivity and organic carbon of soil at different depths

Treatment		pH		Electrical conductivity (mmhos cm^{-1})		Organic carbon (%)	
		1985	1986	1985	1986	1985	1986
Nitrogen (g $tree^{-1}$)							
0	(N_0)	4.89	4.52	0.17	0.16	1.10	1.30
200	(N_1)	4.73	4.32	0.17	0.15	1.13	1.40
400	(N_2)	4.63	4.21	0.19	0.17	1.12	1.37
LSD (0.05)		0.10	0.04	0.01	0.01	0.02	0.07
Weed management practices							
Unweeded control	(M_0)	4.80	4.45	0.18	0.18	1.07	1.27
Atrazine	(M_1)	4.73	4.15	0.17	0.16	1.16	1.39
Oxyfluorfen	(M_2)	4.77	4.19	0.19	0.16	1.08	1.35
Diuron	(M_3)	4.61	4.10	0.17	0.16	1.18	1.37
Grass mulch	(M_4)	4.79	4.60	0.18	0.17	1.26	1.41
Polythene mulch	(M_5)	4.81	4.62	0.16	0.15	1.10	1.38
LSD (0.05)		0.05	0.32	0.01	0.02	0.08	0.10
Depth (cm)							
0-15	(D_1)	4.55	4.17	0.12	0.11	1.44	1.81
15-30	(D_2)	4.75	4.38	0.18	0.16	1.16	1.47
30-60	(D_3)	4.96	4.50	0.22	0.21	0.87	0.91
LSD (0.05)		0.08	0.05	0.05	0.01	0.20	0.05

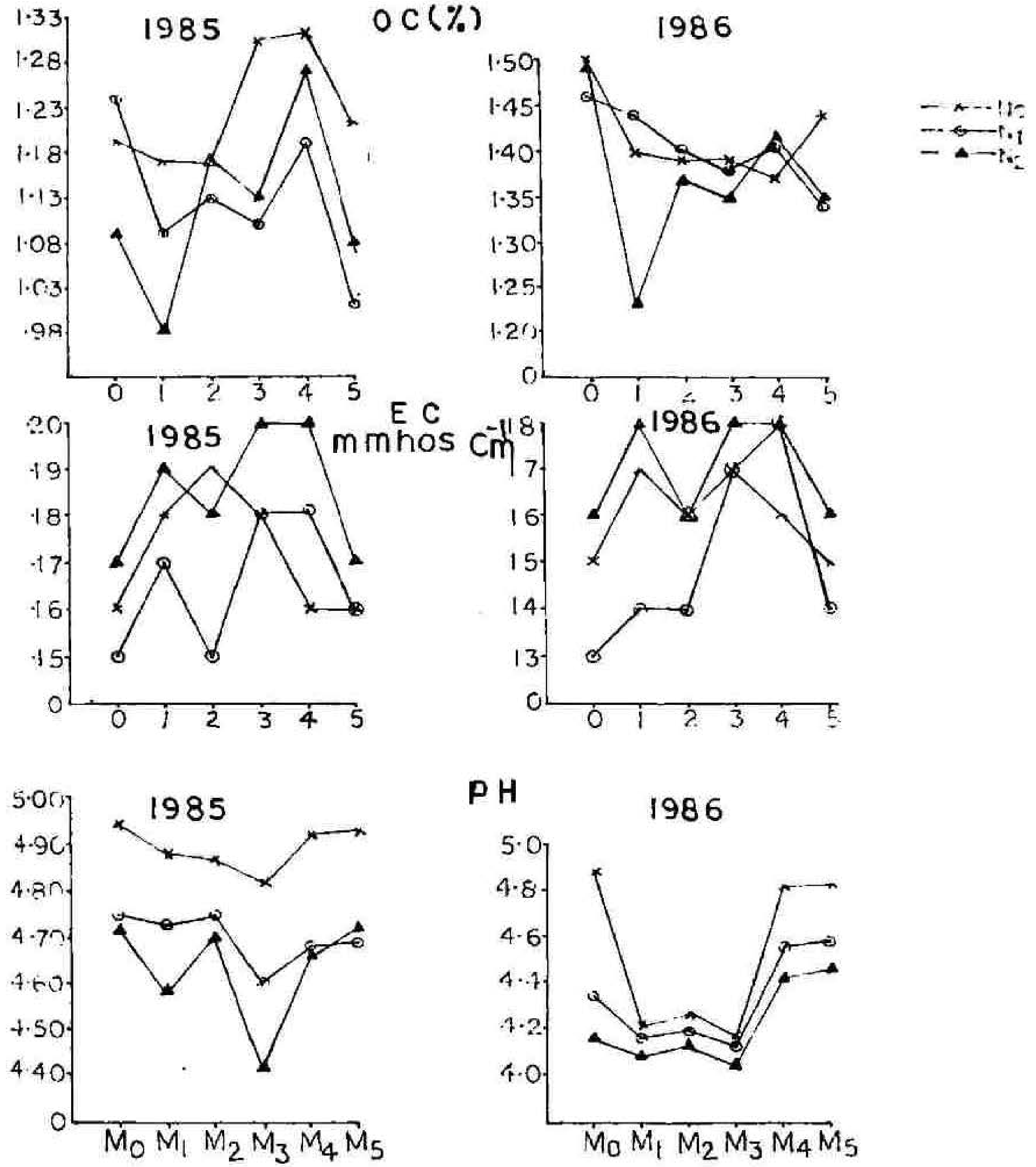


FIG. 10—EFFECT OF N X M INTERACTION ON SOIL PH, ELECTRICAL CONDUCTIVITY AND ORGANIC CARBON AT DIFFERENT DEPTHS

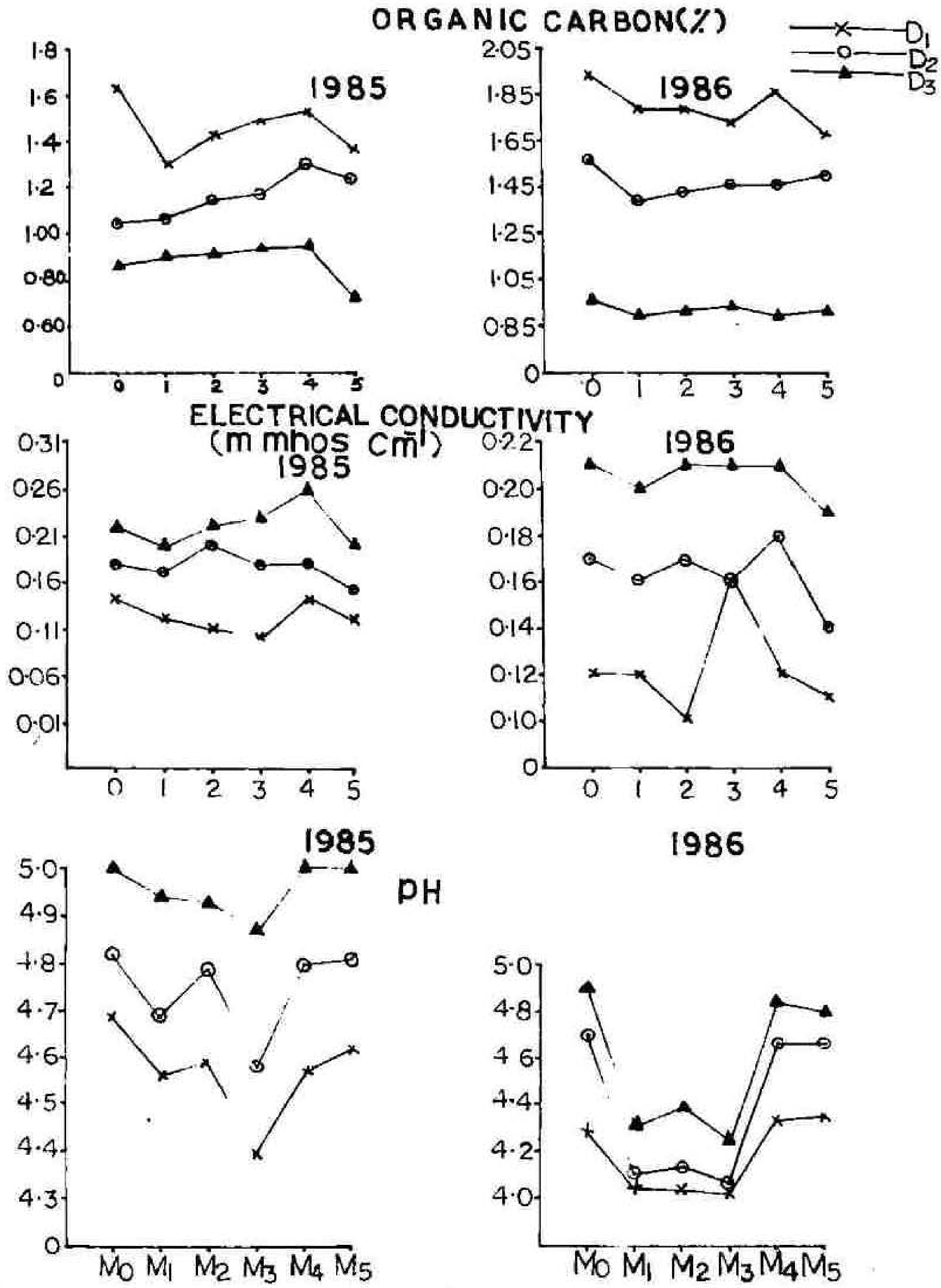


FIG.11 - EFFECT OF M X D INTERACTION ON SOIL PH, ELECTRICAL CONDUCTIVITY AND ORGANIC CARBON AT DIFFERENT DEPTHS

M x D interaction

The interaction between M x D were significant only in 1986. An increase in soil pH with the increase in depth under different management practices was observed. The highest pH value of 4.64 was recorded in M_4D_3 and the lowest value (4.01) was recorded in M_3D_1. Treatment M_0D_3 though at par with M_4D_3 and M_5D_3, yet significantly increased the soil pH compared to rest of the treatment combination(Fig.11).

N x M x D interaction

Soil pH was significantly influenced by the second order interaction only in 1986. The highest pH (5.59) was recorded in $N_2M_4D_3$ which was statistically different from all the treatment combinations. The lowest pH (3.98) was recorded in $N_2M_0D_1$ closely followed by $N_2M_2D_1$(Appendix-13).

4.6.2 <u>Electrical conductivity</u>

Varied N levels, management practices and depths significantly influenced the electrical conductivity of soil. Plots receiving 400 g N, regardless of management practices, had higher electrical conductivity during the year 1985, however, no statistical difference between 0 and 200 g N was observed during both the years.

In both the years, black polythene mulch reduced the electrical conductivity of soil significantly compared to other management practices. In 1985, atrazine and diuron application resulted in decrease in electrical conductivity then rest of the management practices. Whereas, in 1986, all the three herbicides though at par with each other yet reduced the electrical conductivity. The difference between grass mulching and unweeded control was not significant for both the years. The electrical conductivity gradually increased with depth during both the years and the values ranged from 0.11 to 0.22 mmhos cm^{-1}.

Interaction effects

N x M interaction

A study of interaction betwean N and M (Fig.10 and Appendix-12) reveal that the highest level of N under all the management practices increased the electrical conductivity markedly. In 1985, the treatments N_2M_3 and N_2M_4 though at par with N_0M_1, N_0M_3, N_0M_4, N_1M_3, N_1M_4, N_2M_1 and N_2M_2, yet significantly increased the electrical conductivity over all other treatment combinations. Almost similar trend was observed in the subsequent year.

N x D interaction

The influence of N x D on electrical conductivity of soil was observed to be non-significant.

M x D interaction

Like pH, an increase in electrical conductivity with the increase in depth under all the management practices was recorded, but the differences in 1986 were observed to be non-significant. The highest electrical conductivity was recorded in M_4D_3 treatment while the lowest (0.10 mmhos cm^{-1}) was observed under M_3D_1(Fig.11 and Appendix-12).

N x M x D interaction

The electrical conductivity of soil was not influenced significantly by the second order interaction of N x M x D for both the years(Appendix-13).

4.6.3 Organic Carbon

In general, the organic carbon content increased with the increase in N level, however, the differences between 200 and 400 g N was observed to be non-significant during both the years. The grass mulching improved the build up of organic carbon content significantly compared to other management practices in 1985. In the subsequent year, the grass mulching showed its superiority again compared to unweeded control but the differences among rest of the management practices were observed to be non-significant. The organic carbon content decreased with the increase in soil depth throughout the period of investigation. The organic carbon in the surface layer recorded in 1985 and 1986 were 1.44 and 1.81 per cent, respectively. The corresponding values recorded at 30-60 cm depth were 0.87 and 0.91 per cent.

Interaction effects

N x M interaction

The treatment N_1M_5 and N_2M_1 significantly decreased the organic carbon content of soil over N_0M_0 during both the years (Fig. 10 and Appendix-12).

N x D interaction

Like pH and electrical conductivity, the interaction between N x D was recorded non-significant in respect of organic carbon content of soil(Appendix-12).

M x D interaction

The decrease in organic carbon content with the increase in soil depth under different management practices was observed (Fig.11). The lowest value of 0.71 and 0.91 per cent in 1985 and 1986, respectively were recorded in M_5D_3, whereas M_0D_1 exhibited the highest content and the corresponding values recorded were 1.62 and 1.92 per cent.

N x M x D interaction

The differences in organic carbon content of soil due to N x M x D were observed to be non-significant during both the years of study(Appendix-13).

4.7 Available nutrient status of soil

The data pertaining to the effect of N and weed management practices on available nutrient status of soil are presented in Table 4.13.

4.7.1 Available nitrogen

The available N increased with the increase in

N level irrespective of the soil depth and management practices. All the levels of N differed significantly amongst each other. There was a significant difference in the available N content under the different management practices. Diuron application resulted in a significant increase in N build up in soil as compared to other management practices. However, no significant differences were observed among oxyfluorfen, grass mulching and black polythene mulch in 1985. The lower content of available N was recorded under no weeding during both the years.

The available N content decreased significantly with the increase in depth. The surface layer (0-15 cm) exhibited 91.7 and 100.4 ppm N in 1985 and 1986, respectively, while the corresponding values 48.9 and 69.3 ppm were recorded at 30-60 cm depth.

Interaction effects

N x M interaction

In general, the available N increased with the increase in N level under different management practices (Fig.12 and Appendix-14). The highest available N (96.7 ppm) was observed in N_1M_3 treatment in 1985. In the subsequent year treatment N_2M_3 though at par with N_2M_4, yet significantly increased the available N over all other treatment combinations under study. The minimum available N content was recorded in N_0M_0 treatment during both the years under study.

Table 4.13: Effect of nitrogen and weed management practices on macronutrient status(ppm) of soil at different depths.

Treatment		Available N		Available P		Exchangeable K		Exchangeable Ca		Exchangeable Mg	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})											
0	(N_0)	65.5	59.7	6.1	8.9	110.1	106.3	626.7	615.5	100.8	108.5
200	(N_1)	78.4	101.0	6.2	9.0	116.5	116.0	639.6	635.9	108.0	116.5
400	(N_2)	81.8	104.0	6.3	9.0	117.1	117.7	649.3	659.7	118.7	118.8
LSD(0.05)		2.6	1.1	NS	NS	3.2	3.1	6.0	3.6	4.3	1.6
Weed management practices											
Unweeded control	(M_0)	65.9	74.9	5.9	8.3	108.5	107.3	640.0	632.0	107.6	110.1
Atrazine	(M_1)	68.1	85.6	6.1	8.8	113.6	112.2	637.6	632.5	108.9	116.0
Oxyfluorfen	(M_2)	74.8	78.6	6.3	8.6	113.0	111.1	635.7	624.8	108.5	110.5
Diuron	(M_3)	89.2	101.5	6.4	9.5	117.1	116.6	629.7	642.6	110.6	117.5
Grass mulch	(M_4)	73.1	99.0	6.2	9.4	126.5	123.6	655.5	654.5	113.5	121.8
Polythene mulch	(M_5)	70.3	89.9	6.1	9.1	108.6	108.9	632.8	627.3	105.9	111.5
LSD(0.05)		4.4	1.2	NS	0.5	3.6	2.3	14.4	16.4	4.5	3.2
Depth (cm)											
0-15	(D_1)	91.7	100.4	8.9	12.5	146.6	148.6	666.6	664.8	119.9	126.3
15-30	(D_2)	85.1	94.6	5.2	10.2	119.5	115.3	637.4	629.6	108.6	114.2
30-60	(D_3)	48.9	69.3	8.9	4.2	78.6	76.0	611.6	612.4	99.0	103.3
LSD(0.05)		0.5	0.7	0.1	0.1	1.4	2.7	3.5	3.7	1.7	1.3

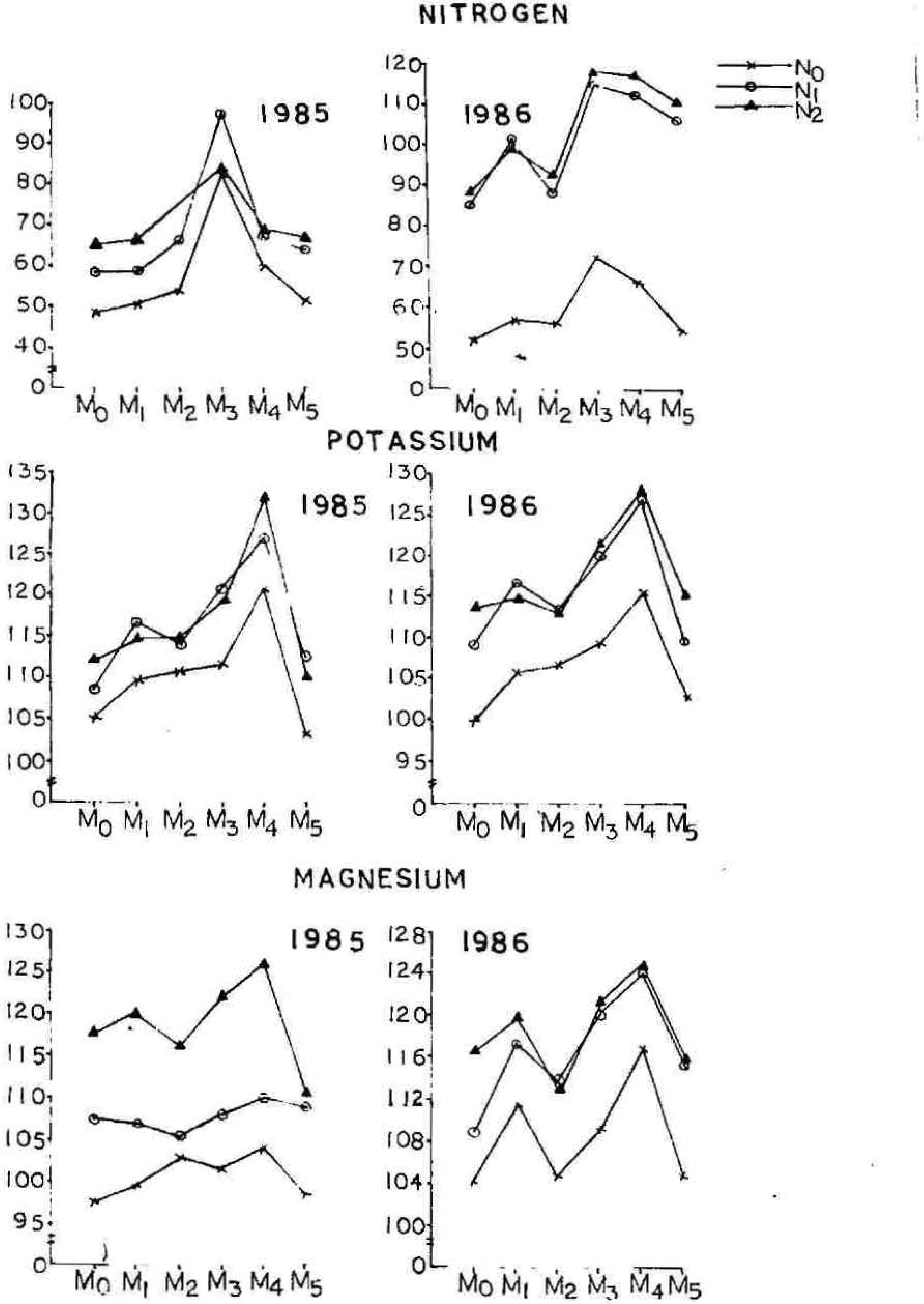


FIG. 12 - EFFECT OF N X M INTERACTION ON THE NUTRIENT STATU
OF SOIL (PPm) AT DIFFERENT DEPTHS.

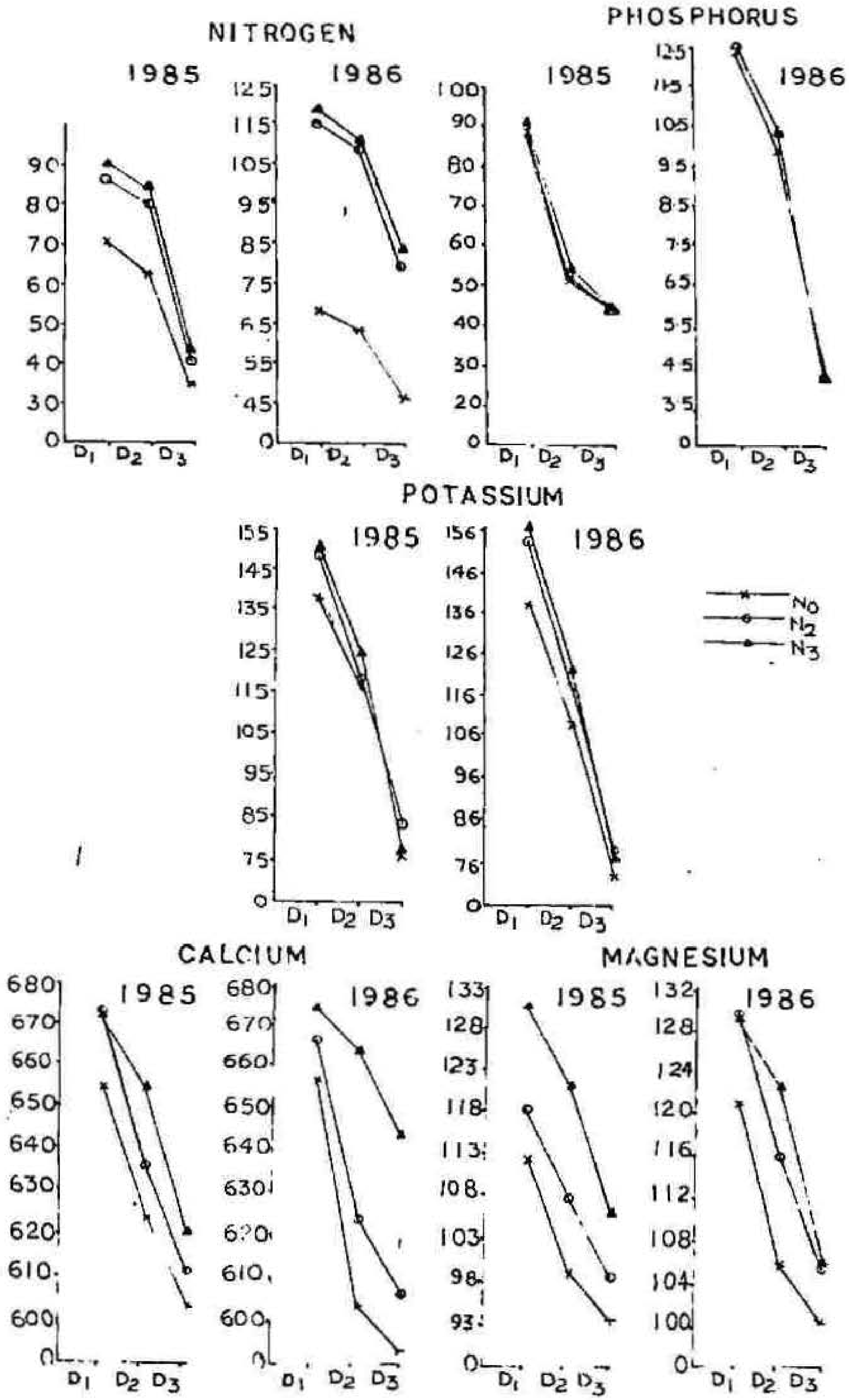


FIG. 13 EFFECT OF N X D INTERACTION ON THE NUTRIENT STATUS OF SOIL (ppm)

N x D interaction

The available N in different depth increased with the increase in N rates. The available N was found to be maximum at surface layer when 400 g N was applied (N_2D_1) and the minimum under N_0D_3 treatment (Fig.13).

M x D interaction

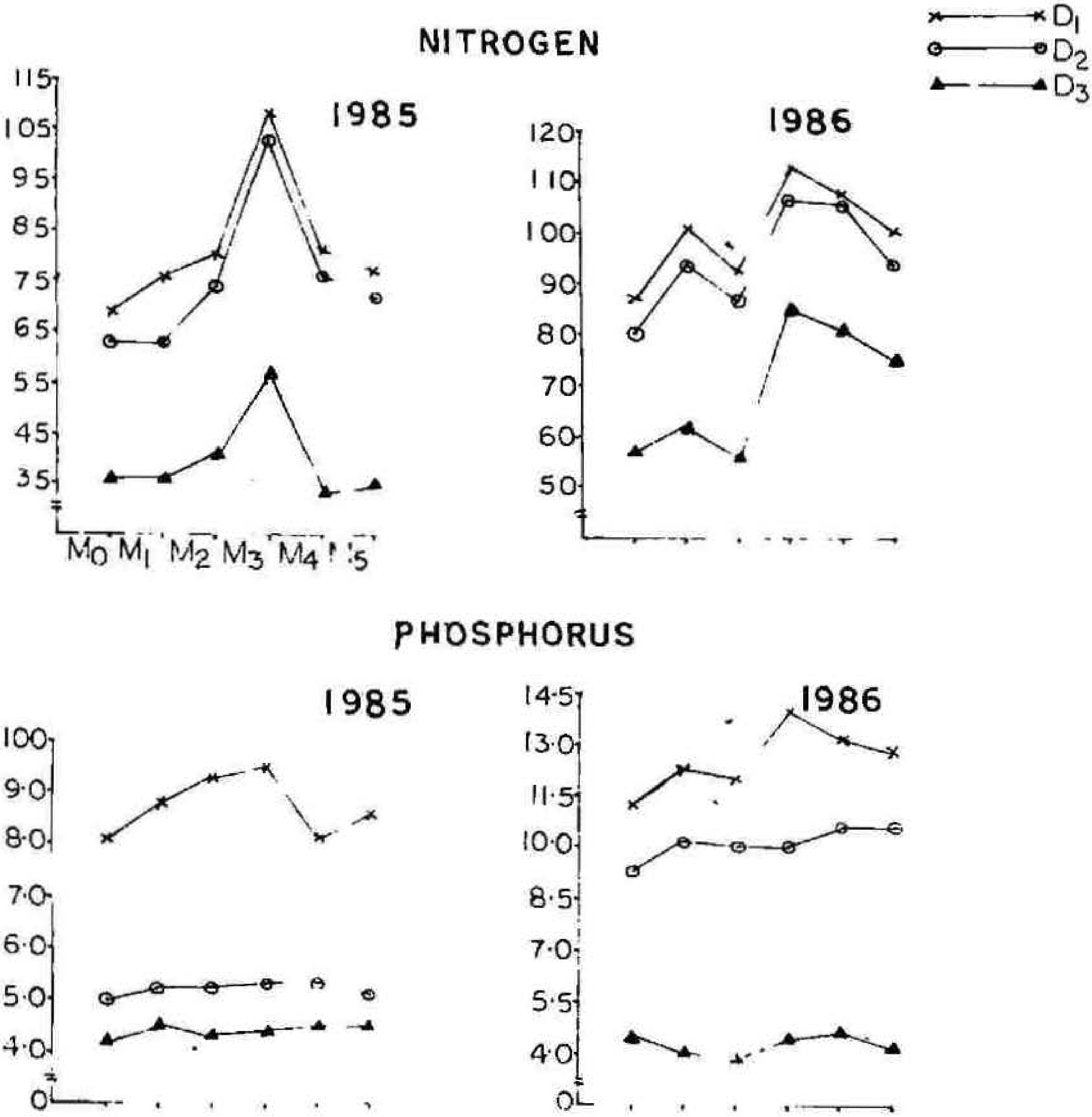
Significantly higher available N content was observed in surface layer receiving diuron (M_3D_1) for both the years. The content of available N was lower under no weeding at all depths (Fig.14).

N x M x D interaction

The available N content of soil was significantly influenced by the second order interaction during both the years of study. The treatment $N_2M_3D_1$ recorded significantly higher N content compared to rest of the treatment combination. In general, the application of diuron improved the build up of available N under all the levels of N and depths. At all the depths, the lower available N was recorded under unweeded control plots(Appendix-15).

4.7.2 Available phosphorus

Different N rates did not affect the available P content of soil throughout the course of study. Data also reveal that the management practices did not affect significantly the status of available P in 1985 but in the



FIG·14-EFFECT OF M X D INTERACTION ON AVAILABLE N AND P OF SOIL (ppm) subsequent year all the management practices except oxyfluorfen increased the available P content significantly compared to unweeded control. Diuron application although at par with grass and black polythene mulching resulted in the highest available P content of soil.

The available P content decreased significantly with the increase in depth. Its concentration was found to be maximum in top layer of soil([illegible].9 and 12.5 ppm in 1985 and 1986, respectively) compared to sub surface layer of 30-60 cm (8.9 and 4.2 ppm in 1985 and 1986, respectively).

<u>Interaction effects</u>

N x M interaction

The interaction effect between N and M on available P content of soil was observed to be non-significant during both the years of study(Appendix-12).

N x D interaction

A study of interaction between N and D showed that treatment N_2D_1 though at par with N_0D_1 and N_1D_1, yet significantly increased the available P content of soil than rest of the treatment combinations during 1985. In the subsequent year, the treatments N_1D_1 and N_2D_1 though at par with N_0D_1 and N_2D_2, yet exhibited the highest available P content of soil. Regardless of management practices, the lowest content of available P was recorded at lower depth (30-60 cm) with all the N levels (Fig.13).

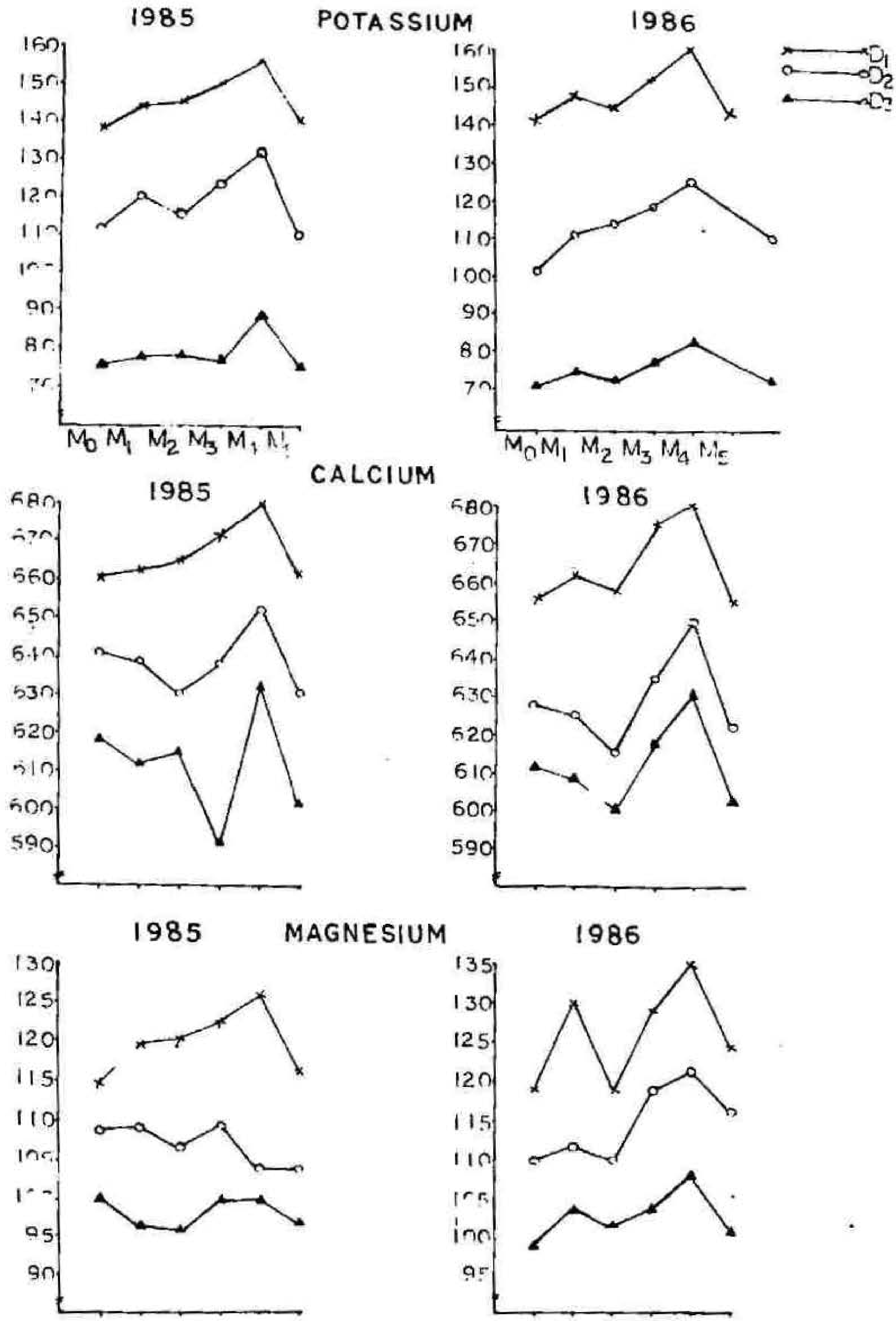


FIG. 15- EFFECT OF M X D INTERACTION ON EXCHANGEABLE K, Ca AND Mg OF SOIL (ppm)

M x D interaction

A perusal of interaction between M x D(Fig.14) reveals that treatment M_3D_1 though at par with M_2D_1, yet significantly increased the available P over all other treatments in 1985. In the subsequent year, M_3D_1 showed significantly higher available P content than rest of the treatment combinations. The lower P content was recorded at 30-60 cm depth under all the management practices.

N x M x D interaction

The interactions due to N xM x D on available P content of soil were observed to be non-significant throughout the course of study(Appendix-15).

4.7.3 <u>Exchangeable potassium</u>

Graded levels of N increased the exchangeable K content of soil, though the difference between 200 and 400 g N was observed to be non-significant. Grass mulching resulted in a significant increase in exchangeable K content as compared to other management practices,however, polythene mulch and unweeded control though at par with each other, resulted in a significant lower K content. Availability of K decreased with the increase in soil depth. Significantly higher K was recorded in the surface layer compared to lower depths. The differences due to varying depths were also significant.

Interaction effects

The interactions between N and M were observed to be significant only in 1986 (Fig.12 and Appendix-14). The exchangeable K content increased with the increase in N level under all the management practices. The treatment N_2M_4 though at par with N_1M_4 increased the K content significantly compared to rest of the treatment combinations. The minimum K content was recorded in unweeded plots where no N fertilizer was applied and it was at par with N_0M_5.

N x D interaction

Regardless of management practices, the exchangeable K content increased with the increase in N level under all the depths. The treatment N_2D_1 though at par with N_1D_1, yet significantly increased the K content over all other treatment combinations. The minimum K content (73.4 ppm) was recorded in N_0D_3 treatment and it was statistically at par with N_1D_3 and N_2D_3(Fig.13 and Appendix-14).

M x D interaction

The interactions between M and D were significant only in 1985 (Fig.15). The treatment M_4D_1 exhibited significantly higher K content than rest of the treatment combinations. The lowest K content was recorded in M_0D_3 closely followed by M_5D_3 which were found statistically at par with M_1D_3, M_2D_3, M_3D_3 and M_4D_3.

N x M x D interaction

The interaction among N,M and D were recorded non-significant during both the years(Appendix-15).

4.7.4 Exchangeable calcium

The graded levels of N increased the exchangeable Ca content significantly and was maximum with 400 g N in both the years of study. Grass mulching resulted in a significant increase in Ca content compared to other management practices. The exchangeable Ca content decreased significantly with the increase in depth. Significantly higher Ca content was recorded in surface layer(0-15 cm) compared to lower depths.

Interaction effects

N x M interaction

The interaction due to N and management practices failed to exert influence on exchangeable Ca content during both the years of study(Appendix-14).

N x D interaction

A perusal of interaction between N and D (Fig.13) reveals that treatment N_1D_1 though at par with N_2D_1,yet significantly increased exchangeable Ca over all other treatment combinations in 1985. In 1986, the treatment combination N_2D_1 raised the exchangeable Ca content significantly than rest of the treatment combinations.

M x D interaction

The interaction of M,D was found to be significant during both the years (Fig.15). The treatment M_4D_1 recorded the highest exchangeable Ca content in 1985, but it was at par with M_3D_1. In 1986 treatment M_4D_1 though at par with M_3D_1, yet exhibited the highest Ca content (631.4 ppm).

N x M x D interaction

Statistical changes in soil Ca content due to N x M x D interactions were witnessed in 1986 only(Appendix-15). The treatment $N_2M_4D_1$ though at par with $N_1M_4D_1$, $N_2M_3D_1$ and $N_2M_4D_2$, yet exhibited the highest Ca content. The minimum Ca content was recorded in $N_0M_5D_3$ and was statistically at par with $N_0M_0D_3$, $N_0M_1D_3$, $N_0M_2D_2$, $N_0M_2D_3$, $N_0M_3D_2$, $N_0M_3D_3$ and $N_0M_3D_2$.

4.7.5 Exchangeable magnesium

A perusal of the data reveals that Mg content of soils were significantly influenced by N levels, management practices and depth. An increase in exchangeable soil Mg was recorded with increase in N level during both the years under study. Grass mulching though at par with diuron resulted in a significant increase in exchangeable Mg content compared to other management practices in 1985. In the subsequent year, grass mulching again resulted in a significant increase in exchangeable Mg content compared to other management practices.

The Mg content decreased significantly with the increase in depth. The Mg content in the surface layer in 1985 and 1986 were 119.9 and 126.3 ppm respectively and the corresponding values of 99.0 and 103.3 ppm were recorded at 30-60 cm depth.

Interaction effects

N x M interaction

A perusal of data (Fig.12 and Appendix-14) reveal that treatment N_2M_4 though at par with N_2M_3 raised the Mg content significantly over other treatment combinations. The minimum exchangeable Mg content was recorded in N_0M_0 in both the years under study. Similarly during 1986, N_2M_4 though at par with N_1M_3,M_2M_3, yet significantly improved soil Mg compared to other treatment combinations. The lowest exchangeable Ca was recorded in N_0M_0 during both the years of study.

N x D Interaction

In general, graded levels of N increased the exchangeable Mg content at different depths. For both years, the treatment N_2D_1 exhibited significantly higher Mg content than the rest of the treatment combinations (Fig.13).

M x D Interaction

Interaction due to M x D were observed to be significant in 1986 only. The treatment M_4D_1 exhibited significantly higher Mg content (129.0 ppm) than rest of the treatment combinations. Minimum Mg content was recorded with M_0D_3 closely followed by M_2D_3 and M_5D_3 (Fig.15).

N x M x D interaction

The interactions due to N x M x D in respect of exchangeable Mg content were observed to be significant only in 1986(Appendix-15). The highest Mg content (136.7 ppm) was recorded in $N_2M_4D_1$ and it was at par with $N_2M_3D_1$, $N_2M_1D_1$, $N_1M_3D_1$, $N_1M_1D_1$ and $N_0M_4D_1$. The treatment $N_0M_0D_3$ reduced the exchangeable Mg content(95.2 ppm) significantly compared to rest of the treatment combinations.

4.8 Correlation coefficients

The simple coefficients of correlation of tree characters, fruit attributes, leaf and soil nutrient status with leaf N or soil N under different management practictices are presented in Table 4.14.

4.8.1 Leaf N

The correlation coefficients between leaf N with tree and fruit attributes under different management practices were observed to be non-significant during both the years. In 1985, leaf N was significantly and positively correlated with leaf Ca, exchangeable K and Mg content of soil(r = 0.848,0.882 and 0.848, respectively). In 1986, leaf K, Mg, available N, exchangeable K and Mg contents of the soil were significantly and positively correlated with leaf N.

4.8.2 Soil N

A perusal of data reveals that in 1985, positive significant correlation existed only between soil and shoot extension growth. In the subsequent year the fruit weight, leaf N, Mg, Zn and available P content of the soil had significant positive correlation with available soil N.

4.9 Soil nitrification

The data regarding the effect of N and wed management practices on the production of NH_4-N and NO_3-N in the soil are given in Table 4.15 and 4.16.

4.9.1 Ammonical nitrogen

A perusal of data reveals that the application of N resulted an increase in the production of NH_4-N on all the sampling dates in both the years of study. The production of NH_4-N was maximum in the soil receiving highest dose of N. The differences due to different rates of N were also significant.

Regardless of N, weed management practices also showed their superiority on the production of NH_4-N on all the sampling dates. Diuron treatment significantly raised the NH_4-N content as compared to other management practices during both the years. No significant differences

Table 4.14: Correlation coefficient of leaf N/soil N on tree growth, fruit attributes, leaf nutrient and available nutrient status of soil

Variable	Leaf N		Soil N	
	1985	1986	1985	1986
Leaf N v/s			Soil N v/s	
A Tree characters				
Girth increment	0.556	0.478	0.059	0.652
Extension growth	0.396	0.124	0.999**	0.474
B Fruit attributes				
Yield	0.446	-0.100	0.693	0.375
Weight	-0.087	0.654	0.035	0.825
Firmness	-0.430	-0.477	-0.155	-0.583
TSS	-0.397	-0.075	-0.130	-0.170
Acidity	-0.239	-0.032	-0.032	-0.402
C Leaf nutrient status				
N	-	-	0.438	0.849**
P	0.428	0.461	-0.278	0.462
K	0.717	0.899**	0.588	0.703
Ca	0.848**	0.760	0.436	0.512
Mg	0.369	0.923**	0.116	0.864**
Fe	0.148	0.193	0.106	0.714
Mn	0.667	0.792	0.029	0.146
Zn	0.714	0.802	0.045	0.924**
Cu	0.464	0.778	-0.092	0.474
D Soil nutrient				
N	0.410	0.849**	-	-
P	0.095	0.179	0.821**	0.991**
K	0.882**	0.975**	0.340	0.774
Ca	0.848**	0.760	-0.409	0.733
Mg	0.399	0.423**	0.363	0.192

** Significant at 5 per cent level

between atrazine and oxyfluorfen could be observed on 1st sampling date in 1985. However, during 1986, the differences between grass and polythane mulch were observed to be at par on all the sampling dates.

The production of NH_4-N due to N x management practices was affected significantly only on the last sampling dates in 1985. The treatment N_1M_3 though at par with N_2M_3 increased the NH_4-N significantly(22.2 ppm) as compared to other treatment combinations. The treatment N_0M_0 produced significantly the lowest NH_4-N content (15.3 ppm). In 1986, no significant differences due to N and M were recorded on all the sampling dates.

4.9.2 Nitrate nitrogen

In general, a direct relationship was observed between N level and NO_3-N production during both the years of study. The maximum production of NO_3-N was recorded in plots receiving 400 g N on all the sampling dates. The differences due to different rates of N were observed to be significant for both the years under study. There was a decrease in the production of NO_3-N after 60 days of herbicidal application during both the years.

The weed management practices increased the total amount of NO_3-N on all sampling dates for both the years. In general, diuron proved superior in increasing the production of NO_3-N significantly compared to other management practices on all the sampling dates.

Table [illegible].15 : Effect of nitrogen and weed management practices on the production of NH_4-N(ppm)

Treatment		Days after application							
		1985				1986			
		30	60	90	120	30	60	90	120
Nitrogen(g tree^{-1})									
0	(N_0)	32.0	37.0	33.4	17.6	27.7	37.7	31.0	17.5
200	(N_1)	36.4	42.0	41.1	19.0	31.2	40.7	36.9	21.4
400	(N_2)	42.6	48.7	47.2	20.9	37.4	45.6	40.9	24.2
LSD (0.05)		1.4	2.0	1.8	0.9	1.5	2.6	2.3	1.3
Weed management practices									
Unweeded control	(M_0)	34.0	38.9	37.9	19.0	29.9	33.8	29.9	17.5
Atrazine	(M_1)	37.8	42.7	40.6	19.9	33.6	43.3	40.3	23.3
Oxyfluorfen	(M_2)	35.6	40.9	38.3	17.8	30.6	37.5	33.1	18.4
Diuron	(M_3)	41.0	50.0	45.7	21.2	36.9	52.9	47.0	30.2
Grass mulch	(M_4)	38.3	42.5	41.0	19.3	32.0	37.4	34.5	18.6
Polythene mulch	(M_5)	35.4	40.4	39.8	17.7	30.3	36.1	32.6	18.2
LSD (0.05)		2.4	1.8	1.9	0.8	2.2	3.8	2.5	3.4
N x M interaction									
	N_0M_0	28.1	33.7	32.2	15.3	23.5	28.0	25.5	14.0
	N_0M_1	33.4	37.5	33.9	18.2	29.9	35.1	32.7	22.0
	N_0M_2	31.7	36.7	31.3	17.7	27.2	31.6	26.7	15.2
	N_0M_3	36.0	44.5	37.5	19.8	33.2	44.8	43.8	25.3
	N_0M_4	34.3	35.6	33.1	18.8	27.3	31.8	30.5	14.3
	N_0M_5	28.2	34.2	32.5	15.6	25.1	31.1	26.9	14.8
	N_1M_0	33.5	37.9	33.4	15.4	28.4	33.8	29.9	17.2
	N_1M_1	36.9	42.0	37.3	19.4	32.0	45.0	41.9	25.1
	N_1M_2	34.6	40.2	41.6	18.6	29.8	37.9	33.2	18.1
	N_1M_3	41.5	50.2	37.8	22.2	35.7	52.8	46.6	30.1
	N_1M_4	37.6	42.6	47.0	19.4	31.6	37.6	35.0	19.3
	N_1M_5	34.4	39.1	41.8	19.1	29.8	30.7	34.9	18.7
	N_2M_0	40.0	45.1	44.2	18.9	35.7	39.6	34.3	21.3
	N_2M_1	43.1	48.5	46.4	21.7	38.8	49.7	46.4	23.4
	N_2M_2	40.5	45.7	45.9	20.4	35.0	43.1	39.3	22.0
	N_2M_3	45.5	55.5	52.7	22.1	41.7	58.6	50.6	35.3
	N_2M_4	43.1	49.3	48.2	20.7	37.0	42.4	38.0	22.7
	N_2M_5	43.7	48.0	40.8	20.7	35.9	40.5	36.1	21.6
	LSD (0.05)	NS	NS	NS	1.4	NS	NS	NS	NS

Table 4.15 : Effect of nitrogen and weed management practices on the production of NO_3-N(ppm)

Treatment		Days after application							
		1985				1986			
		30	60	90	120	30	60	90	120
Nitrogen(g tree^{-1})									
0	(N_0)	29.2	33.2	29.1	23.4	18.9	25.6	21.8	17.4
200	(N_1)	36.7	41.5	37.0	31.3	21.6	31.7	24.7	21.2
400	(N_2)	42.2	46.5	42.2	35.9	22.7	38.4	30.2	26.0
LSD(0.05)		0.2	1.3	1.2	0.7	1.9	1.0	1.4	1.6
Weed management practices									
Unweeded control	(M_0)	29.3	32.3	28.5	22.4	19.4	27.3	20.0	16.4
Atrazine	(M_1)	36.9	41.5	36.8	31.5	21.4	33.6	27.9	22.6
Oxyfluorfen	(M_2)	32.7	36.6	31.8	26.1	20.8	29.2	21.9	17.9
Diuron	(M_3)	44.7	49.9	45.8	38.1	23.6	40.3	33.8	24.9
Grass mulch	(M_4)	41.1	46.3	42.2	36.4	20.9	33.1	27.5	24.1
Polythene mulch	(M_5)	32.5	35.9	31.7	26.7	20.2	28.1	22.4	19.1
LSD(0.05)		0.8	1.6	3.2	3.3	0.8	1.0	1.5	1.4
N x M interaction									
	N_0M_0	22.8	25.5	21.6	15.9	17.9	21.4	15.7	11.7
	N_0M_1	30.0	34.7	29.8	23.6	19.1	28.1	22.5	19.5
	N_0M_2	25.5	30.5	26.4	21.8	18.7	20.8	18.0	14.2
	N_0M_3	36.6	41.2	37.6	30.3	22.5	31.4	29.9	24.2
	N_0M_4	35.4	38.9	34.7	28.7	19.6	27.7	23.1	19.3
	N_0M_5	25.1	28.6	24.6	19.8	18.3	22.3	21.8	15.7
	N_1M_0	28.5	33.8	28.7	22.2	20.3	27.4	19.5	16.1
	N_1M_1	37.9	41.2	37.6	32.5	22.4	32.0	27.3	23.0
	N_1M_2	33.2	37.5	32.2	26.1	21.3	28.7	21.5	17.3
	N_1M_3	45.6	51.3	45.3	41.1	24.2	39.1	32.1	28.3
	N_1M_4	41.2	46.6	42.4	36.8	20.3	34.3	27.3	24.4
	N_1M_5	33.7	38.8	34.1	29.3	19.9	28.5	20.3	18.2
	N_2M_0	33.6	37.5	35.3	29.2	20.0	33.1	24.8	21.4
	N_2M_1	43.1	48.7	43.0	38.5	22.9	40.3	33.8	25.3
	N_2M_2	39.4	41.7	36.7	30.4	22.3	36.1	26.1	22.1
	N_2M_3	52.0	27.3	52.5	42.7	25.9	50.3	38.5	35.6
	N_2M_4	46.7	53.5	49.5	43.6	22.6	37.3	32.2	26.5
	N_2M_5	38.6	40.7	36.5	31.0	22.5	33.4	25.2	23.5
LSD(0.05)		NS	NS	NS	NS	1.4	1.7	2.7	2.5

Higher production of NO_3-N was recorded in 1985 as compared to 1986.

The interactions between N x M were observed to be significant only in 1986(Table 4.16). All combinations of 400 g N with either of the management practices exhibited higher production of NO_3-N on all the sampling dates. The treatment N_2M_3 differed significantly and gave higher content than rest of the treatment combinations on all the sampling dates. The minimum NO_3-N content was recorued in N_0M_0 and it differed signficantly from rest of the combinations.

4.10 Soil microflora

The data pertaining to the effect of N and management practices on fungi, bacteria and actinomycetes population are presented in Tables 4.17 to 4.19.

4.10.1 Fungi

A perusal of data (Table 4.17) reveals that fungi population in soil increased with increasing level of N on all the sampling dates. In 1985, the differences due to different levels of N were significant on all the sampling dates except at 90 days where the differences, between 200 and 400 g N were observed at par. In 1986, the differences between 200 and 400 g N were observed to be at par on first two sampling dates, thereafter, the significant differences were recorded even upto last date of sampling.

Table 4.17: Effect of nitrogen and weed management practices on fungi population($\times 10^4$)

Treatment		Days after application									
		One		30		60		90		120	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})											
0	(N_0)	11.5	11.1	12.2	12.0	13.2	12.3	16.3	13.6	12.2	11.3
200	(N_1)	13.4	12.2	15.2	13.3	16.9	13.9	20.3	15.0	14.5	12.7
400	(N_2)	15.8	12.9	17.2	14.3	18.8	15.0	22.2	16.3	16.2	14.4
LSD (0.05)		0.3	1.1	1.3	1.1	1.2	0.7	2.3	0.6	0.5	0.9
Weed management practices											
Unweeded control	(M_0)	9.8	10.2	10.4	11.1	10.3	11.7	11.7	13.1	9.7	10.9
Atrazine	(M_1)	12.7	12.0	14.0	12.8	15.5	13.3	18.2	15.2	14.1	12.2
Oxyfluorfen	(M_2)	16.4	13.6	19.1	14.2	19.7	15.1	25.2	16.1	16.1	14.0
Diuron	(M_3)	18.0	14.7	19.3	15.7	21.3	16.5	28.4	17.5	18.3	14.7
Grass mulch	(M_4)	14.0	12.1	16.0	12.7	16.4	13.9	23.3	14.5	16.3	13.2
Polythene mulch	(M_5)	9.2	10.0	11.5	10.9	13.1	12.7	11.8	13.5	11.5	11.7
LSD (0.05)		0.8	0.9	1.0	1.1	1.5	0.9	2.9	1.2	1.1	0.9
N x M interaction											
	N_0M_0	7.0	9.0	7.2	10.0	8.0	8.0	7.5	10.7	7.2	8.2
	N_0M_1	11.2	10.7	12.0	11.2	12.7	11.7	15.2	13.2	12.7	10.2
	N_0M_2	15.0	13.0	15.7	13.5	17.0	14.0	22.5	15.2	14.0	13.0
	N_0M_3	15.7	14.0	17.0	15.0	18.7	16.2	27.7	17.0	16.5	14.0
	N_0M_4	12.7	11.2	13.0	12.2	14.0	13.0	16.7	13.5	13.7	12.2
	N_0M_5	7.5	9.0	8.5	10.2	9.0	11.0	8.0	12.0	9.2	10.0
	N_1M_0	10.5	10.5	11.2	11.2	13.0	12.2	12.7	13.7	10.5	11.2
	N_1M_1	12.0	12.0	14.0	13.0	16.2	13.2	19.0	14.2	14.0	12.2
	N_1M_2	15.7	13.7	18.2	15.0	20.0	15.2	26.5	16.0	16.2	13.0
	N_1M_3	20.7	15.0	8.7	16.0	21.8	16.0	28.0	17.2	18.2	14.2
	N_1M_4	13.2	12.0	15.7	13.0	17.0	14.0	24.0	14.7	16.0	13.2
	N_1M_5	8.2	10.0	12.0	11.5	14.2	13.0	11.5	14.0	12.0	12.0
	N_2M_0	12.0	11.0	[illegible].7	12.0	15.2	13.2	14.5	14.7	11.2	13.2
	N_2M_1	15.0	13.2	[illegible].0	13.7	17.5	15.0	20.2	18.0	15.5	14.0
	N_2M_2	18.5	14.0	[illegible].2	14.2	22.0	16.0	26.7	17.0	18.0	16.0
	N_2M_3	20.0	15.2	2[illegible].2	16.0	24.0	17.2	19.5	18.2	20.2	15.7
	N_2M_4	16.0	13.0	1[illegible].2	13.0	18.0	14.7	26.2	15.2	19.2	14.2
	N_2M_5	12.0	11.0	140	11.0	16.0	14.0	16.0	14.5	13.0	13.2
LSD (0.05)		NS	NS	N	NS	NS	NS	NS	NS	NS	NS

All the management practices in general, raised the fungi population significantly compared to no weeding. Polythene mulching raised significantly fungi population compared to unweeded control on second, third and last date of sampling during the first year of experimentation. However, during 1986, the differences between polythene mulch and unweeded control were not significant on all the sampling dates except after 60 days from herbicidal application. Diuron significantly gave higher fungi population followed by oxyfluorfen on all the sampling dates during both the years. The interactions between N and M on fungi population were not significant on all the sampling dates during both the years.

4.10.2 Bacteria

Graded levels of N increased the bacterial population significantly and was maximum with 400 g N. Bacterial population increased periodically upto 90 days, thereafter decline in population was recorded. The differences between 0 and 400 g N were observed to be significant on all the sampling dates except the first one.

All the management practices influenced the bacterial population significantly(Table 4.18). As with N, the bacterial population increased under all the management practices upto 90 days. Thereafter, the population tended to decline. Diuron application maintained significantly higher bacterial population than rest of the management practices during both the years of experimentation. The

Table 4.1.3 Effect of nitrogen and weed management practices on the bacterial population ($\times 10^7$)

Treatment		Days after application									
		One		30		60		90		120	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})											
0	(N_0)	9.4	11.0	13.2	14.5	36.7	37.4	64.2	61.7	25.8	24.3
200	(N_1)	9.8	11.2	28.5	30.0	68.4	69.6	77.8	72.6	29.3	28.3
400	(N_2)	11.7	13.5	30.4	31.4	74.7	75.3	74.4	71.1	27.4	26.7
LSD (0.05)		1.7	1.1	2.3	1.8	5.2	4.0	6.4	3.2	3.2	2.2
Weed management practices											
Unweeded control	(M_0)	8.2	9.5	16.7	17.8	43.7	43.1	24.5	42.9	21.9	28.0
Atrazine	(M_1)	10.2	12.6	21.6	23.2	59.8	61.0	36.0	72.2	27.5	30.3
Oxyfluorfen	(M_2)	12.3	14.5	26.9	28.5	66.7	67.8	14.1	82.1	32.0	32.6
Diuron	(M_3)	16.5	17.7	34.7	35.9	88.5	89.8	50.1	96.5	33.3	32.8
Grass mulch	(M_4)	7.4	8.3	23.4	24.3	59.4	61.1	34.1	64.8	27.6	28.3
Polythene mulch	(M_5)	7.0	8.3	20.5	21.5	41.9	41.8	30.1	56.6	22.6	26.0
LSD (0.05)		1.8	1.5	1.2	2.0	3.6	21.6	4.0	4.2	2.3	1.5
N x M interaction											
	N_0M_0	7.2	8.0	9.0	8.0	20.2	18.7	22.0	8.5	21.0	7.5
	N_0M_1	10.2	12.7	11.7	10.5	35.0	36.5	67.2	69.2	26.7	28.0
	N_0M_2	11.2	14.2	15.5	13.5	45.7	46.7	83.5	84.5	30.0	30.0
	N_0M_3	13.2	15.7	28.2	26.7	62.0	64.0	94.0	94.5	32.0	32.5
	N_0M_4	6.2	7.7	12.7	11.2	38.7	40.7	60.5	61.2	24.2	25.7
	N_0M_5	6.2	7.5	10.0	9.0	18.2	17.5	53.2	52.5	21.0	21.0
	N_1M_0	8.2	9.7	21.5	20.0	50.3	54.2	60.5	62.7	21.2	8.5
	N_1M_1	9.2	11.5	28.7	26.7	67.5	69.0	77.2	78.0	31.5	32.0
	N_1M_2	10.2	12.0	32.5	31.5	74.2	75.2	87.0	88.0	33.7	35.0
	N_1M_3	16.2	17.5	39.0	37.7	93.0	93.7	98.2	97.7	34.5	35.5
	N_1M_4	7.7	8.7	30.2	29.0	71.0	72.5	73.2	74.2	30.0	30.7
	N_1M_5	7.0	7.5	27.0	25.7	57.7	58.0	65.7	64.7	24.7	28.0
	N_2M_0	9.0	11.0	23.0	22.2	56.2	56.2	59.5	57.5	23.5	31.0
	N_2M_1	11.2	13.5	29.5	27.7	77.0	77.5	71.5	69.5	24.2	31.7
	N_2M_2	11.5	17.2	36.7	35.7	80.8	81.5	75.7	74.0	32.2	31.0
	N_2M_3	18.2	19.5	40.5	39.7	102.7	111.7	108.5	97.5	33.5	30.0
	N_2M_4	8.2	10.0	31.5	30.0	68.5	70.0	71.0	59.0	28.7	23.7
	N_2M_5	8.0	9.7	25.5	26.7	55.7	55.0	61.5	51.2	22.2	26.0
LSD (0.05)		NS	NS	NS	2.2	6.3	NS	7.0	7.3	NS	2.7

minimum population was recorded in unweeded control.

The interaction due to N and M failed to influence the population of bacteria on the first sampling date during both the years. Likewise no significant differences were observed after 30 and 120 days of herbicidal application in 1985 and at 60 days in 1986. The treatment N_2M_3 resulted in significant higher bacteria population compared to other management practices on all the sampling dates except the last one. On all the sampling dates, the lowest bacteria count was recorded in N_0M_0.

4.10.3 Actinomycetes

It is evident from (Table 4.19) that N application exerted significant influence on actinomycetes counts on all the sampling dates except at 60 and 120 days interval during 1985. In general, the actinomycetes population increased with the increase in N application, however, the differences between 200 and 400 g N were observed at par after 1 and 60 days of herbicidal application during 1986. The higher actinomycetes counts were noticed on first sampling date and thereafter a decline in population was noticed.

The different management practices recorded significant influence on actinomycetes population on all the sampling dates. The actinomycetes count were significantly higher under diuron compared to other management practices. The difference between black polythene

Table 4.19 : Effect of nitrogen and weed management practices on actinomycetes population(x 10^4)

Treatment		Days after application									
		One		30		60		90		120	
		1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
Nitrogen(g tree^{-1})											
0	(N_0)	43.4	33.6	10.1	11.2	7.9	8.7	6.5	7.4	3.2	3.7
200	(N_1)	68.5	37.6	11.2	12.6	9.1	10.1	7.5	8.6	3.6	4.8
400	(N_2)	51.6	35.6	20.5	20.1	10.0	11.1	6.7	9.7	3.4	4.3
LSD(0.05)		2.7	3.0	1.1	5.8	NS	1.2	0.9	0.7	NS	0.5
Weed management practices											
Unweeded control	(M_0)	35.3	19.3	10.8	11.9	7.3	7.5	7.0	7.7	4.4	5.1
Atrazine	(M_1)	59.7	38.3	14.4	15.4	9.0	10.0	7.8	9.0	2.8	3.3
Oxyfluorfen	(M_2)	76.4	56.5	15.5	16.7	11.5	12.5	9.8	10.4	4.0	4.8
Diuron	(M_3)	89.3	61.5	17.7	18.9	13.0	14.2	10.5	11.5	4.2	5.2
Grass mulch	(M_4)	65.3	19.9	14.5	12.9	7.6	8.3	6.3	7.0	3.8	4.5
Polythene mulch	(M_5)	40.8	18.0	10.7	11.3	6.1	6.6	4.8	5.8	3.1	1.5
LSD(0.05)		9.5	3.0	1.7	0.9	1.0	1.2	1.2	0.2	0.7	0.5
N x M interaction											
	N_0M_0	17.2	16.2	9.0	10.0	6.5	7.2	6.0	6.7	4.2	4.2
	N_0M_1	39.7	36.2	10.0	11.2	8.2	9.0	6.7	7.7	2.5	2.3
	N_0M_2	77.5	55.0	71.7	13.0	10.5	11.5	8.2	9.0	3.5	4.0
	N_0M_3	90.7	60.0	13.7	15.2	12.2	13.5	9.0	10.0	4.5	5.1
	N_0M_4	64.0	17.2	8.2	9.2	5.7	6.2	5.5	6.2	3.5	4.1
	N_0M_5	26.2	16.7	8.0	8.7	4.5	5.0	1.3	5.0	1.0	1.2
	N_1M_0	44.0	20.2	9.7	11.2	7.0	8.0	6.7	7.7	4.6	5.1
	N_1M_1	72.7	40.2	11.0	12.5	8.7	10.0	7.7	9.2	3.2	3.3
	N_1M_2	86.5	59.2	12.0	13.2	12.0	13.0	9.2	10.7	4.2	5.0
	N_1M_3	94.7	65.0	14.2	15.2	13.0	14.0	10.2	11.2	4.0	5.1
	N_1M_4	65.0	21.7	10.2	10.7	7.5	8.5	6.5	7.2	4.5	5.0
	N_1M_5	48.0	19.0	10.0	10.0	6.5	7.2	5.0	5.5	1.2	1.2
	N_2M_0	44.7	21.5	13.7	14.5	8.5	9.2	8.2	8.7	4.5	5.2
	N_2M_1	67.7	38.5	22.2	22.5	10.2	11.2	9.0	10.0	2.7	3.2
	N_2M_2	70.2	55.2	23.0	24.0	12.2	13.0	10.5	11.5	4.5	5.2
	N_2M_3	82.5	59.5	25.2	26.0	14.0	15.0	12.2	13.2	4.2	5.1
	N_2M_4	67.0	20.7	25.0	19.7	9.7	10.2	7.0	7.7	3.5	4.1
	N_2M_5	49.2	18.2	14.2	15.2	7.5	7.7	5.7	7.0	1.2	1.3
LSD(0.05)		16.5	2.9	2.9	1.6	NS	NS	NS	NS	NS	NS

and unweeded control was at par after 30 days of herbicidal application in 1985 and at 30 and 60 days in second year. The polythene mulching exhibited the lowest actinomycetes counts on all the sampling days except the first one in 1985.

The interactions between N and management practices on actinomycetes population were observed to be significant only 1 and 30 days after herbicidal application. On first sampling date the highest actinomycetes population was obtained in N_1M_3 closely followed by N_0M_3 and N_1M_2 during first year of experimentation while in subsequant year it was statistically different from rest of the treatment combinations. The minimum actinomycetes count were noted in N_0M_0 on the first two sampling dates.

CHAPTER - V

DISCUSSION

DISCUSSION

Mineral nutrition of fruit trees considerably influence the uptake of nutrients, root distribution, weed population, growth and productivity of fruit trees. Chemical weed control is a modern practice and has been adopted in many advanced countries. The traditional practice of mulching is commonly used by the fruit growers to conserve moisture and to increase the availability of nutrients. In the present investigation, the influence of different levels of N under different management practices were studied and results obtained on weed control, growth, yield, quality parameters, uptake of nutrients and soil characteristics have been discussed as follows:

5.1 Weed studies

5.1.1 Weed flora

Different levels of N increased weed population and dry weight of weeds. The increase in monocot and dicot weeds population with the increasing levels of N in the present study is understandable in view of general role of this element on growth of green plants. Since N is essential to plant growth, its application in soil will obviously trigger the weed germination and growth. Similar findings have been reported by Bhatia (1982), Jayant (1984) Khokhar(1984) and Bhan(1986).

The weed management practices significantly reduced the weed population. However, the weed control effect of black polythene mulch was much pronounced than grass mulch which was closely contested by diuron. The effect of mulches in weed population reduction may be attributed to the fact that under mulching, weeds are controlled by etiolation and act as a physical barrier for the newly emerging weeds(Robinson and O'Kennedy,1978; Jayant,1984; Sharma,1985).

All the three herbicides namely atrazine, oxyfluorfen and diuron reduced weed population significantly. Among the herbicides, the highest weed control was obtained with diuron closely followed by oxyfluorfen. Significant control of weeds by atrazine and diuron observed in the present investigation is in conformity with the findings of other workers(Dolby and Putnam,1980; Daniell,1981; West et al.,1983; Sharma,1986; Bhan, 1986). The herbicides used in the present investigations are systemic and are applied to the soil as preemergence to weeds. The foremost function of the soil acting herbicides is to prevent the germination of viable weed seeds or retard the growth of weed seedlings. All the three herbicides exerted inhibitory effect in one or more of the phases of seedling growth, i) early germination i.e. the emergence of radicles ii) seedling establishment at the expense of endosperm or cotyledonary reserves iii) Growth of seedling after the seed reserves are exhausted. Inhibitory effect of atrazine, diuron and oxyfluorfen is generally accompanied by failure of the metabolism of seed reserves. There is marked sensitivity of early weed seedlings growth to the preemergence herbicides (Cartwright,1976). Herbicides are often absorbed by the roots of young growth weed plants and transported to the foliage via transpiration stream or apoplast and exert an inhibitory effect on photochemical oxidative phosphorylation and respiration.

The triazines and substituted urea herbicides have usually been shown to inhibit the growth of intact plants and this has been attributed to the blockage of photosynthesis. The most sensitive site of action of these herbicides in photosynthesis is photosystem II (Vostrol et al. 1970; Moreland and Hilton,1976). Currently it is widely accepted that both diuron and atrazine involves the blockage of electron transport between Q (Primary electron acceptor for PS-II) and PQ (Plasto Quinone). This prevents the formation of ATP and NADPH, which are required for carbon dioxide fixation (Ashton and Crafts,1981). Histological studies have shown that atrazine causes accelerated vacuolation in the cells, disintegration of chloroplasts in the leaves, cessation of chemical activity and a lesser thicnkess of cell wall of sieve and tracheary elements of the stem. Cytological investigations have shown that the fine structure of the chloroplast is greatly altered by treatment with atrazine (Ashton and Crafts, 1981). All of these effects were observed only in the light, but not in dark, thus indicating that these inhibitory effects are associated with photosynthetic processes.

Oxyfluorfen, a diphenylether herbicide, causes the stomata to close as a result of increased membrane permeability (Gonske and Hopen,1978). They also noticed stimulation of ethylene synthesis causing loss of plastids from the bundle sheath cells and finally leaf abscission. Oxyfluorfen requires light for its activity. Vanstone and Stohle (1979) found that oxyfluorfen treated plants were not injured in the dark, but when they were placed in light the plants showed injury symptoms. The rate of injury increased as light intensity increased. Pritchad et al.(1980) reported that photosystem II linked phosphorlylation and photosystem II electron transport were inhibited by oxyfluorfen. They reported that the rapid membrane disruption by oxyfluorfen in light suggests either (a) photooxidation of cell components through interactions with plant pigments (b) injury due to oxyfluorfen induced toxic compounds or (c) interference from a more basic biosynthetic reaction which is required for the prevention of photooxidative destruction.

A marked decrease in both monocot and dicot weed population was observed in 1986 compared to 1985, which is explained in the light of fact that besides the residual effect of herbicides which tended to persist in the subsequent years, the herbicides were required to take care of lesser weed population because of more efficient kill in the first year. This fact is also borne out from the data on dry weight of weeds(Table 4.4) where reduction can be noted in second year compared to the first year. These findings lend a credence to the earlier observation of Bhutani et al.(1983), Khokhar(1984) and Sharma (1985) where significant reduction in weed population and dry weight of weeds was recorded in the second year as compared to the first year.

5.1.2 Nutrient removal by weeds

The macronutrient removal by weeds increased with the increase in level of N but decreased under mulching and herbicidal spray which was due to proportional increase or decrease in weed population. The minimum nutrient removal in plots where no N was applied may be attributed to the lesser weed density per unit area compared to the ones supplied with higher N doses which consequently accumulated a higher dry matter. Many workers have reported increase in nutrient removal by weeds due to N application in stone fruit orchards(Bhatia and Bhutani,1983; Jayant,1984; Bhan,1986).

The macronutrient removal by weeds were significantly low under mulching and herbicidal treatments. This was due to lower weed population and reduced dry weight under these treatments. Jayant(1984) also reported minimum losses of nutrient with herbicides and mulching in plum orchards. Similar reduction in nutrient removal due to herbicidal application in stone fruits has been reported (Bhan et al.,1983; Sharma,1986).

With the increase in N levels, there was a corresponding increase in the nutrients removal by weeds under different management practices. Haese (1977) while working with 'd' Anjou pear reported increased levels of N reduced the effect of triazine and triazole herbicides.

5.2 Tree productivity

5.2.1 Growth

Nitrogen application significantly increased the growth of tree in terms of trunk growth, shoot extension growth and pruning weight. Several workers have reported an increase in tree vigour due to N fertilization in peaches (MuCunn,1933; Ritter,1965; Baroccio and Manzo, 1966; Baxter,1974; Monstra et al.,1975; Kanwar,1979). Sharma and Singh (1982) found that 120 g N per year age of plant produced significantly greater trunk growth as compared to the lower dose of 0.5 and 1.0 kg of N. The possible reason for the increased growth with the increasing level of N might have been, i) the higher availability of N content (NH_4^+, NO_3^- and total N in the soil), ii) higher N content in various parts of the tree, iii) better development of the root system of the tree. Truog (1973) cited numerous investigations to indicate the beneficial effect of soil fertilization and he observed that the main effect was to increase the assimilation processeses. N is associated with all vital life processes, therefore a sufficient supply of various nitrogenous compound is required in each plant cell for the proper functioning. The increase in growth under black polythene mulch and herbicides is possibly due to increased availability of nutrients and moisture in combination with reduced weed growth. The weeds consume large amount of nutrients and moisture and, therefore, reduction in their population enables roots to exploit great surface area for moisture and nutrients uptake. Atkin and White (1977) claimed that herbicidal treatment increased the root density and activity in first 15 cm layer of soil profile resulting in greater uptake of moisture and nutrients leading to vigorous growth in apples. In fact, mulching influence growth of different fruit crops through its moderating effect on hydrothermal regime of the soil.

In the present study there were no differences in the trunk diameter under different weed management practices. Gleen (1963), Dhuria et al. (1976) and Bhan(1986) did not find any difference on trunk diameter due to herbicidal application. Recently, Gian (1987) found no influence of clean cultivation, mulching and sod culture on trunk girth and cross-sectional area of Red Delicious apple trees.

5.2.2. Yield

The results show that fruit yield per tree increased by N application. Many researchers have reported increase in yield in peaches due to N application(Cahoon, 1971; Uchiyama, 1973; Orphanos, 1974; Baxter, 1974; Lenina et al. 1977; El-Banna et al. 1981). Maximum cropping by the use of N are largely explained in terms of an improving N status of the tree which increased both the initial set and final number of fruit compared to the lowest rate. Increase in yield may also be attributed to increase in auxin synthesis as a result of N application and reduced abscission (Addicot and Lynch, 1955). Significantly lower yields recorded during 1986 as compared to 1985 may be attributed to the high atmospheric humidity and fluctuation in temperature at the time of flowering and fruit setting. A perusal of meteorological data recorded during 1985 and 1986 (Appendix-1) would show that while during 1985, the humidity and temperature remained fairly uniform while in 1986 these were particularly at the time of flowering and fruit setting.

The yield tree^{-1} was highest with diuron followed by grass mulching during the first year of experimentation. In the subsequent year diuron though at par with oxyfluorfen maintained its superiority. Better build up of nutrients due to efficient weed control and soil moisture conservation under these management practices probably might have increased the yield. Jayant(1984) also reported increased yield with herbicide followed by mulching plus herbicide treatment in Santa Rosa plum.

5.3 Fruit quality

Optimum nutrition is always associated with the production of high quality fruit. Fruit quality in general is improved by N fertilization as well as by weed management practices.

Fruit weight and size increased with increase in N levels while the total soluble solids, total sugars remained unaltered with enhanced N fertilization. However, the reducing sugar content of fruit decreased with the increase in levels of N. The increase in fruit size and weight may be attributed to higher cell division, and photosynthetic activities. Further N application has been reported to prolong the phase of fruit cell division in apricot resulting in greater number of cells per fruit. (Albriso et al.,1966). Brown and Raebsting(1962) and Sharma et al.(1979) also reported an increase in fruit size in peaches with the increase in N supply. According to Hansen(1970) photosynthates supplied to fruit by leaves and fruit act as a metabolic 'Sink' which was probably higher on account of N fertilization. The reduction in reducing sugar content of fruit with increased level of N is not understandable but it may result due to utilization of sugar in the synthesis of amino acids, amides and proteins. Chandel (1985) also recorded a reduction in reducing sugars with N application in apricot.

In contrast to 1986, the fruit quality was considerably influenced during 1985 a year of heavy fruit crop. In general, heavy bearing trees produce poor quality fruits as compared to low cropped year. The increase in acid content of the fruits at higher level of N is perhaps due to increased synthesis of organic acids and their translocation to the fruit (Baldini,1960). These results are in agreement with those of Bhutani et al. (1983) and Chandel (1985) who reported an increase in fruit acidity with N application in plum and apricot, respectively.

The grass as well as polythene mulching produced fruit with higher weight and size. The increase in fruit size due to mulching may be due to increased nutrient and moisture availability. The unweeded control recorded the minimum values for the above. This is attributed to low moisture and nutrient uptake by the trees. Further increase in fruit size under black polythene may be due to reduction in yield tree^{-1} as observed in the present investigation. The weed management practices in general decreased the firmness and TSS content of fruit. The reduction in fruit firmness due to management practices may be due to slightly early maturation. The reduction in TSS observed in the present study was probably due to dilution effect as a result of heavy crop load. Gautam (1980) also observed a reduction in TSS content as a result of long term use of herbicide in Santa Rosa plum. The grass mulching and herbicides were instrumental in increasing the acidity and reducing sugars. Such an increase in acidity and reducing sugars may be due to increased uptake of nutrients by the trees as a result of efficient weed control. Belyaeva and Zavarzin(1968) also observed an increase in monosacchrides with the use of herbicides in peaches.

5.4. Leaf nutrient status

Nitrogen application increased the leaf N content significantly but the differences between 200 and 400 g N were at par with each other during 1986. Since N is highly mobile , its efficient translocation to the leaves could have aided its accumulation in the leaves(Smith,1962). Nitrogen at the rate of 200 and 400 g were statistically similar in term of leaf N status which might be due to impaired uptake at higher doses and the cause appeared to be the accumulation of ammonia from the applied fertilizer inducing toxicity to the enzymes responsible for N metabolism in the plant (Dev Choudhary,1979; Srivastava and Mathur,1982). The leaf N content was found in optimum range at both the levels of N in comparison to the values given by Shear and Faust(1980). Many others reported increased N content in the leaves with the increasing level of N content in the leaves with the increasing level of N fertilizer(Ritter,1956; Gammon and Shoemaker, 1964; Stembridge et al.1962; Stojkovska et al.1972; Leece,1976).

The leaf P content was not influenced by different levels of N. The leaf K, Ca and Mg content decreased with the increased N levels. The existance of antagonism between N andK could account for depressed K level in leaf (Ballinger et al.,1966). Ritter(1956) concluded that in peach leaves, high N and high K contents are never possible together because of the antagonistic relation. Failure of N application to raise the Ca level in leaves may be related to the slow mobility of Ca in plant tissues (Norten and Wittwer, 1963). Leece (1976) reported that N application decreased K,Ca and Mg content of leaf while Gammon and Shoemaker(1964) reported reduction in P and K.

In general, leaf Fe, Mn,Zn and Cu increased with increased N levels, but the highest dose had a deterimental effect on Cu, which could be attributed to the increased vegetative growth. Thus the dilution factor might have been operative. Such a relationship has been found in other fruit plants also (Voth et al.,1961; Joiner and Dickey,1961).

Awada and Long (1978) working on 'Solo' variety of Papaya found that N increased Mn and Zn concentration in the petioles. This might be the result of increased solubility of these metals due to the use of N fertilizers which aciditified the soil. They further reported that Fe and Cu also rose with increased N fertilization. An increase in Fe,Zn and Cu have been reported by Leece(1976) in peach.

The combined effect of N and weed management practices resulted in increased macro and micronutrient accumulation in leaves because management practices reduced competition by weeds for nutrient and moisture, thus, resulting in more availability of nutrients to the plants. Atkinson (1974) observed that herbicidal treatment increased the density and activity of roots in the top 15 cm layer of soil profile. So the increased availability of nutrients and root growth on the surface may increase uptake of nutrients by plants. Grass mulch and herbicides particularly diuron proved better in improving the leaf nutrient status. With herbicide or mulch, competition from weeds and mechanical damage to the roots are eliminated. The roots can,therefore, exploit a greater volume of soil particularly the surface layer. Further, the better moisture conditions and higher temperature at the surface layer in the absence of weeds also encourage nutrient uptake. Similar response has been obtained by various researchers where weeds were eliminated by herbicide or mulching (Ries et al.,1963; Fideghelli et al., 1975; Atkinson et al.,1982;Johnson and Johnson,1982;Jayant,1984).

5.5. Nutrient status of fruit

Increased N levels increased fruit N, whereas a decrease in the uptake of K, Ca and Mg was observed with increase in N levels. The decrease in the nutrients may be due to the antagonistic effect and poor translocation to fruits from shoot and leaves. In the present studies, CU and Zn content of the fruit remained unaffected. Similar findings have been reported by Sharma (1986) and Sud(1987). Grass mulching proved better in improving the nutrient status of fruit. It was probably due to the better availability of the moisture and considerable amount of nutrient in the soil as mulch might have added nutrients considerably after decomposition. Tromp (1980) observed an increase in the uptake of Ca and K under normal moisture regime as compared to soil under water deficit.

5.6. Soil properties

The application of N drastically reduced soil pH. The decreased in soil pH due to N application may be the result of the chemical breakdown of fertilizer applied. Similar reduction in soil pH due to fertilizer has also been reported (Aquino et al.,1976; Sinha et al.,1983; Bhan,1986; Sud,1987). The acidity due to N arises when NH_4^+N is converted to NO_3^-N in the soils. The additional acidity arises from presence of anions of NH_4^+ fertilizers.

Significant decreased in soil pH following the use of herbicides as recorded in the present study have often been reported by many investigators (Banwell, 1972; Atkinson and White,1976). The increase in soil acidity after prolonged herbicide use in orchards appears to be both a common and wide spread occurrence. The mechanism involving in the pH drop need further investigation, although it has been suggested (Haynes,1980) that the leaching of cation such as Ca and Mg of the surface soil may be responsible. Increased salt concentration generally result in a drop in measured soil pH partly because cation in soil solution can undergo cation exchange acidity hence releasing acid in the soil solution(Atkinson and White 1976).

Soil pH was lowest at surface layer and it increased with the increase in soil depth. This could be due to the increased aciditification of the surface soil resulting from the conversion of NH_4^+- N during ammonification to NO_3^-- N which releases the H^+ ions.

Higher electrical conductivity was recorded at 400 g N while 0 and 200 g N levels were at par. Higher electrical conductivity at higher N level was the result of addition of more salts in the form of nitrogenous fertilizer. Many workers have reported increase in soil electrical conductivity by the application of N fertilizer (Badyal,1980; Jayant,1984; Sud,1987) in stone fruit.

Diuron and atrazine application decreased electrical conductivity of soil and under grass mulch it remained unaffected. The decrease in electrical conductivity due to herbicides is attributed to decrease in soil pH and thus releasing various ions from the surface layer. The increase in electrical conductivity due to increase in depth may be due to release of various cations from the exchange complex and accumulation in the sub-surface horizons (Tisdale and Nelson,1975).

A marked increase in organic carbon content of the soil was recorded with increased N supply. The increase in leaf size and number due to N application yielded heavy turnover of the biomass during leaf fall, which on decomposition resulted an increase in the organic matter of the soil. Further, increase in the root density of tree due to N application may enhance the organic matter of the soil at the time of decomposition. Biswas et al.(1977) reported that fertilizer stimulated the acidity of microorganisms resulting in rapid decomposition of organic residues. The stimulation of microbial population due to N application has also been recorded in present study.

The highest organic carbon content was observed under mulching during both the years of study. The increase in organic carbon content of the soil is understandable from the fact that grass mulching leaves its residue in the soil, thereby, adding large amount of organic matter. Further, evidence to this effect can be cited from the work of Gour and Mukherjee(1980) which demonstrated that straw mulch increased the organic carbon content of fallow and cropped soil by 7 and 25 per cent, respectively. The various reasons put forth in support of higher organic matter formation are higher number / volume of roots due to reduced temperature owing to fewer wetting and drying cycles in summer months and consequently adding to the build up of organic matter.

The herbicidal application also raised the organic carbon build up as compared with unweeded control. The higher organic carbon build up may be due to higher turnover of tree leaves into the tree basin, thus, resulting in a sufficient organic residues build up even in the absence or partial elimination of weeds. The organic carbon content decreased with increase in soil depth, regardless of either of the treatments applied. This may be due to natural addition of vegetative debris occurring mostly in the upper layer of profile and less weathering in deeper soil segments. Several workers have reported decrease in organic carbon content of soil with the increase in depth (Chawla,1969; Sankhyan,1972;Bhan,1986).

5.7. Available nutrient content of soil

The available N content of soil increased progressively with the increasing levels of N. This increase is possibly as a result of N fertilizer directly contributing towards the available N pool and due to higher biomass production which is an indirect store house of N after it is being mineralised (Black,1968; Parur et al.,1973). Nitrogen also activated the microbial degradation of organic matter which releases ample quantities of N (Duggal,1966). Similar findings have been reported in peach by Vitanova (1973).

The herbicides and grass mulching resulted in higher available N content. The highest available N was recorded with diuron. Lacknova(1978) ,Khokhar(1984) and Bhan (1986) also obtained an increase in available N due to application of substituted urea herbicides. The increase in N content may be due to effective weed control and thereby reducing the competition for nutrients. Grass mulching resulted in the increase in N build up probably on account of higher organic carbon and low leaching losses of N from the soil. Presence of higher microbial population as observed in the present study(Table 4.17 to 4.19) due to N application and grass mulching could also be responsible for degradation of organic matter,thereby, releasing N. In the presence of microorganisms the uptake of inorganic and organic metabolites is increased and this might have increased the available N in the soil.

Available P content was not influenced by N application. Bhatia (1982) reported no effect of N application on the P content of soil. However, available P was increased with mulching and herbicides. Effect of grass mulching was significant in increasing the available P which was possibly due to the addition of grass mulch and further its decomposition. Quastel(1965) found that microbial breakdown of organic matter is associated with an increased Co_2 production which possibly increases the solubility of soil phosphate. The presence of optimum moisture may also have resulted in the build up of P from the soil. Furthermore, the greater P availability by grass mulching and N application may also be attributed to the increased acidity of P solublizing bacteria and fungi in the soil.

The exchangeable K,Ca and Mg content increased with the increase in N levels. The increase in acidity due to N fertilizer application might have favoured solubilisation of K,Mg and other cations(Kanwar,1976). Naik and Ballal (1968) reported that increased N supply increased the soil K availability. The application of N fertilizers directly influence the microbial population which consequently increased the fertility of soil.

The herbicides, in general, increased K and Mg content of soil while a reduction in exchangeable Ca due to harbicides was recorded. The increased in available nutrients may be due to effective weed control and increase in organic carbon content of soil(Bhatia,1982; Khokhar,1984; Bhan,1986).

Available K,Ca and Mg contents of the soil were higher under grass mulching. Higher amount of available nutrients has also been reported by Jayant(1984) in plum orchard under grass mulching plus herbicides. This may be due to decomposition of mulching material and higher availability off nutrients on account of favourable moisture.

Wallace (1958) reported that increase in moisture in well aerated soils resulted in an increase of nutrients. An increase in K,Ca and Mg has been reported by Brown(1960). Experiments conducted by Delver(1980) showed higher accumulation of K in the upper soil layers by the application of large amount of grass mulch.

Maximum amount of available nutrient were recorded in the surface layer and decreased markedly with the increase in depth. Several researchers have reported that amount of nutrients decreased with increasing depth. (Bhandari,1973; Kanwar,1979; Ganai et al.,1982; Bhan,1986) possibly due to less weathering and low organic carbon content in the sub-surface soil.

5.8. Correlation coefficients

In the present study the available N content in the soil were significantly and positively correlated with the shoot growth. The direct influnces of N fertilization on tree vigour and yield are well documented in fruit crop. For instance Kanwar and Nijjar (1982) while working on 'Flordasun' peach found that higher levels of N produced significantly greater tree growth as compared with lower levels of N. In apple, Batjer and Westwood(1963) observed significantly increased trunk circumference with the higher N application.

The leaf N was found to be positively correlated with leaf Ca as well as with available N and Mg content in the soil. Such positive correlations have also been observed by Khokhar(1984) and Bhan(1986) in plum. On the contrary, most of the fertilizer experiments have shown that with an increase in the rate of N fertilization, P, Zn and K correlation in citrus leaves is decreased(Embleton et al., 1963; Smith, 1966).

5.9. Nitrification of soil

The transformation of N increases mineralization of organic N ammonical form which in turn is oxidised to NO_3^- in two steps by two autotropic bacteria namely *Nitrosomonas europae* and *Nitrobacter agilis*. The decomposition of organic matter in soil contributes about 80 per cent for the formation of ammoniacal N and oxidation of this form provides the NO_3^- – N which is readily absorbed by higher plants. Therefore, any stimulation or inhibition of bacterium will be directly responsible for ultimate NO_3^-–N production in the soil.

The effect of N levels on the NH_4^+ and NO_3^- content were found to be significant. Their concentration in the soil increased progressively with increasing level of N. The ammonical and nitrate N showed its peak at 60 days which prolonged upto 90 days. Thereafter a decline was observed during monsoon period. Similar type of results have been obtained by Puranik et al.(1978), Yaduvanshi (1980) and Bhan (1986). Such an increase is quite evident because the fertilizer added provides a substrate for various microbes responsible for nitrification processes. The decrease in level of NH_4^+–N and NO_3^- – N in the soil during monsoon period may be due to excessive moisture content in the soil. Bhan(1986) reported similar type of seasonal variation in NH_4^+ and $N\bar{O}_3$ content in plum orchard soil. Mandal and Chonkar (1984) reported that the rate of nitrification processes depends to a greater extent on varying environmental as well as soil factors, such as soil aeration, moisture, temperature, soil reaction and mineral

All the management practices increased the production of NH_4^+ and $N\bar{O}_3$— N. Diuron application increased the production of both NH_4^+ and $N\bar{O}_3$— N followed by grass mulch. The stimulation of NH_4^+ and $N\bar{O}_3$—N as observed in present investigation with the application of herbicide corroborate with the findings of Tavestlova (1966), Setty et al.(1970) and Bhan(1986) who reported an increase in nitrate production by the addition of triazine herbicides and decomposition of grass mulch and/or the stimulation of microorganisms as well as the mineralization of N in the soil.Kulinska(1967), Grossbard and Davis(1976), Kolisnikov and Sidorov(1978) and Bhan(1986) also reported a stimulatory effect of herbicides on the soil nitrification processes. There have been numerous reports which tend to show that herbicides at normal rate do not affect nitrification adversely. The present study too tends to indicate that herbicides application at normal field rates do not affect or stimulate nitrate production.

Soil moisture also exerts a strong influence on the nitrification process. It appears that adequate moisture which resulted due to mulching exerted a strong influence on the nitrification processes. Russel(1967) reported that the rates of nitrification are appreciably affected by various soil moisture content in the soil.

5.10. Soil microflora

The population of fungi, bacteria and actinomycetes was found to increase with the application of N. The fungal and bacterial population increased upto 90 days and decrease afterwards, while in case of actinomycetes the maximum population appearred on first sampling date. Nitrogen is important for protein synthesis which is food for the microorganisms and this might have increased the population. Almost all the essential nutrients needed for growth of higher plants and animals are also required by microorganisms. Venkatarao et al.(1972) recorded an increase in microbial population by the application of N and P. Bhutani and Bhatia (1984) reported that increased N doses had no effect on bacteria but stimulated actinomycetes and fungi population in plum orchard.

In general, herbicides increased microbial population. A number of workers have reported the stimulation of microorganism by use of herbicides(Mashtakov et al.1962; Akopyan,1978; Bhutani et al.,1983; Jayant,1984; Bhan,1986). When herbicides are applied to soil, they were bound to influence the growth and activity of microorganisms in the surrounding ecosystem beside mitigating the growth of weeds. It has been reported that certain species of bacteria are capable of utilising triazine herbicides as supplementary or sole source of carbon and N (Kaufman and Kearney,1964). Further certain bacteria like *Xanthomonas* spp., *Sarcina* spp. and *Pseudomonas* spp. have been shown to metabolise the urea as the chief source of carbon (Hill et al.,1955). This was the probable reason for an increase in the bacterial population due to herbicides as recorded in the present study. It is well established that grass mulching supplies large amount of carbon in addition to N. The microorganisms are capable of using carbon and N furnished by the decomposition of grass mulching. This possibly be the reason for higher microbial population under combination of grass mulching and N. The reduction in microbial population particularly under black polythene mulch may be due to rise in temperature of soil and poor aeration.

From the foregoing discussion it can be inferred that application of N at the rate of 400 g tree^{-1} increased tree vigour, yield and improved the quality of Shan-e-Punjab peach in conjunction with grass mulching or herbicidal spray. Application of herbicide particularly diuron at 4 kg ha^{-1} along with N fertilizer have provided acceptable level of weed control and improved the leaf and fruit nutrient status. The available nutrient status was also improved by N,herbicides and mulching. No phytotoxic effect such as leaf chlorosis, leaf curling, fruit drop, fruit deformation or reduction in tree growth and yield could be noticed owing to the herbicidal application.

CHAPTER - VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigations were carried out in the experimental orchard, Department of Pomology and Fruit Technology, Himachal Pradesh Krishi Vishva Vidylaya, Palampur during 1985 and 1986. The results obtained are summarised below:

6.1. Both monocot and dicot weed population increased significantly with the increase in N levels. All weed management practices reduced significantly the weed population. Black polythene mulch proved more effective in controlling weeds.

6.2. Dry weight of weeds and macro-nutrient removal by weeds increased significantly with the increase in the levels of N. However, there was a decrease under herbicides and mulching. The lowest dry weight and nutrient losses were recorded under polythene mulch.

6.3. Trunk girth was not affected by weed management practices but showed an immense improvement by N levels. The maximum trunk girth was recorded under grass mulching with highest level of N(400 g tree^{-1}).

6.4. The extension growth and pruning weight were significantly increased with increase in N levels. 400 g N in combination with diuron resulted in maximum pruning weight.

6.5. Fruit yield was enhanced significantly both by N application and weed management practices. Application of 400 g N in combination with diuron or grass mulching significantly increased the fruit yield.

6.6. The fruit size improved significantly with increase in N levels during 1986. Application of 400 g N in combination with grass mulching resulted maximum increase in fruit size.

6.7. The fruit firmness decreased with N levels. Unweeded control recorded maximum firmness followed by grass mulch. TSS content of fruit remained unaffected by N levels. The weed management practices influenced the TSS content only in 1985. Application of 400 g N with atrazine increased the TSS significantly.

6.8. Per cent acidity increased significantly upto 200 g N during 1985, but in the subsequent year no significant influence as a result of N application was recorded. Grass mulch reduced the per cent acidity in 1985 but the interactions between N levels and weed management practices were observed to be non-significant during both the years.

6.9. The total sugars were not affected due to N levels. However, the highest contents were recorded under no weeding closely followed by oxyfluorfen.

6.10. Nitrogen application improved leaf N, Fe, Mn, Zn and Cu, whereas, the uptake of K, Ca and Mg was reduced.

Leaf P remained unaffected due to N levels. The leaf N,K,Ca,Mg,Mn and Cu were significantly increased under grass mulching. The treatment combination of 400 g N with grass mulching improved the leaf nutrient status markedly.

6.11. Increased N application enhanced fruitNbut did not alter P, Mn and Cu. Increased N rate decreased the K and Ca content of fruits. The fruit Mg content was significantly increased with the application of N during 1986. The highest content of fruit N,K,Ca ,Mg ,Fe, Mn, Cu and Zn were recorded under grass mulching,while P content remained unaffected due to weed management practices.

6.12. Both N and herbicides reduced the soil pH, which, however, increased with the increase in depth. The highest pHwas recorded in black polythene mulch closely followed by grass mulch.

6.13. Higher electrical conductivity was recorded at higher levels of N. Polythene mulch decreased the electrical conductivity significantly. The highest electrical conductivity was recorded at 30-60 cm depth.

6.14. The organic carbon content increased significantly by N application and grass mulching. Appreciably reduced organic carbon was recorded at lower depths.

6.15. The available N and exchangeable K, Ca and Mg content of soil were significantly improved by different N levels, while P content remained unaffected. Diuron treated plots exhibited more N and P. Grass mulching significantly raised the exchangeable K,Ca and Mg content in the soil. Significantly lower amount of available nutrient were recorded at sub-surface layer compared to the surface layer.

6.16. NH_4^+ and NO_3^- — N contents increased progressively with the increasing level of N application. Amongst the weed management practices, diuron proved to be effective in increasing these contents. The availability of NH_4^+ and NO_3^-— N content of the soil was higher from 60-90 days after herbicidal application.

6.17. The fungi population increased with the addition of N, herbicides, and grass mulching. Among the herbicides, diuron asserted its superiority in increasing the fungi population and the effect persisted even upto 60 days of application. A similar trend was observed with bacterial population but the effect remained constant upto 90 days of application. Actinomycetes population was significantly affected upto 30 days of herbicidal application.

Conclusion:

The present investigation suggest that the application of 400 g N with grass mulching or diuron at 4 kg ha^{-1} provides acceptable level of weed control and thereby maintain an optimum nutrient status conducive for healthy growth,tree vigour and cropping in Shan-e-Punjab peaches.

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APPENDICES

APPENDIX-I

Meteorological data for the period from January, 1985 to January, 1986

Month	Temperature (^oC)		Relative humidity (%)	Total rainfall (mm)
	Max.	Min.		
		1985		
January	14.2	4.4	66	72.7
February	17.8	6.4	72	27.4
March	23.7	11.5	69	26.4
April	25.9	14.7	56	80.2
May	31.0	18.8	46	51.6
June	31.5	20.2	42	99.5
July	27.7	19.6	77	677.3
August	24.4	19.7	82	863.0
September	25.1	17.3	71	363.5
October	22.8	12.9	57	133.0
November	19.9	8.9	41	0.0
December	16.8	6.5	47	141.7
		1986		
January	15.2	4.5	44	-
February	15.4	6.0	52	127.8
March	19.2	19.3	51	110.3
April	25.4	14.2	35	50.8
May	27.0	15.9	43	101.4
June	29.5	20.2	48	387.0
July	25.4	19.7	78	948.2
August	25.7	18.9	77	709.5
September	26.0	16.9	60	151.6
October	23.2	13.0	53	63.4
November	20.8	10.0	46	89.6
December	15.3	5.5	50	58.6

APPENDIX-2

Effect of interaction between N and weed management practices on monocot weed population (m^{-2})*

Treatment	Days after application							
	1985				1986			
	30	60	90	120	30	60	90	120
N_0M_0	10.8	11.4	12.2	14.4	10.4	10.8	12.0	16.2
N_0M_1	9.2	10.4	11.0	13.2	7.2	7.4	7.8	14.4
N_0M_2	8.4	9.2	9.4	12.0	6.6	6.8	8.2	13.4
N_0M_3	8.2	9.0	9.4	12.0	5.4	5.6	7.6	13.6
N_0M_4	9.2	10.0	10.4	12.8	4.8	5.4	5.8	13.2
N_0M_5	7.8	8.6	8.8	10.2	5.4	4.8	4.8	13.0
N_1M_0	11.6	12.0	12.2	14.4	11.0	11.2	12.2	17.2
N_1M_1	10.0	10.8	11.2	13.4	8.0	8.2	8.4	14.6
N_1M_2	9.0	9.6	9.6	12.2	6.8	7.2	7.4	13.8
N_1M_3	9.6	9.8	10.0	12.0	5.6	5.8	5.8	13.8
N_1M_4	10.0	10.6	10.8	13.0	6.4	6.6	7.6	14.0
N_1M_5	8.6	9.0	9.2	10.4	5.4	5.6	6.0	13.8
N_2M_0	12.2	12.4	12.8	14.6	11.2	11.4	12.2	17.2
N_2M_1	10.4	11.0	11.4	13.4	8.6	9.2	8.4	15.0
N_2M_2	9.8	10.0	9.6	12.4	6.8	7.0	7.8	14.0
N_2M_3	9.8	9.8	10.2	12.4	6.0	6.0	6.2	14.0
N_2M_4	9.8	11.0	11.0	13.2	7.6	7.2	7.8	15.0
N_2M_5	8.8	9.4	9.6	11.2	6.4	6.0	6.2	14.0
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

* $\sqrt{n+1}$ transformed values

APPENDIX-3

Effect of interaction between N and weed management practices on dicot weed population(m^{-2})*

Treatment	Days after application							
	1985				1986			
	30	60	90	120	30	60	90	120
N_0M_0	4.8	6.0	6.2	11.0	6.4	7.4	9.0	11.2
N_0M_1	3.8	4.6	5.4	9.2	3.4	6.6	8.6	9.2
N_0M_2	3.2	3.8	4.0	7.8	3.0	3.8	3.8	7.6
N_0M_3	3.0	3.6	3.8	7.4	2.8	3.8	3.6	7.0
N_0M_4	2.8	3.6	4.6	7.8	2.6	3.2	5.0	7.6
N_0M_5	2.4	3.2	3.6	5.8	2.0	3.0	3.4	4.8
N_1M_0	5.6	7.0	7.4	11.0	6.8	8.0	9.6	11.8
N_1M_1	4.0	5.2	5.6	9.8	6.7	7.0	9.0	9.4
N_1M_2	4.0	4.4	4.8	7.8	3.8	4.2	5.0	7.8
N_1M_3	3.8	4.2	4.4	8.2	3.4	3.8	4.8	7.2
N_1M_4	3.4	4.4	4.8	7.8	3.4	5.4	6.0	8.4
N_1M_5	3.2	3.8	4.0	7.0	1.4	3.6	4.4	7.0
N_2M_0	6.6	8.2	8.0	13.2	7.4	8.4	9.6	12.0
N_2M_1	5.4	6.0	6.0	10.0	6.8	7.4	9.0	9.4
N_2M_2	4.8	5.2	5.0	8.2	4.2	4.8	5.0	8.2
N_2M_3	4.6	4.6	4.6	8.2	4.2	4.6	4.8	7.8
N_2M_4	3.8	5.0	5.4	9.4	3.6	6.0	6.4	9.4
N_2M_5	3.4	4.6	4.4	7.4	2.8	4.2	4.8	6.4
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

* $\sqrt{n+1}$ transformed values

APPENDIX-4

Effect of interaction between N and weed management practices on dry weight of weeds (g m^{-2})* and nutrient removal by weeds (kg ha^{-1})

Treatment	Dry weight of weeds		N		P		K		Ca		Mg	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	15.1	13.9	25.4	16.2	6.5	3.1	63.4	28.5	7.0	5.0	5.8	5.2
N_0M_1	14.7	11.5	21.0	11.0	5.0	2.5	41.5	12.5	4.1	2.8	4.1	3.2
N_0M_2	10.8	10.2	16.8	8.9	3.5	1.1	37.2	19.3	3.9	2.0	3.9	3.1
N_0M_3	10.0	9.5	13.2	6.2	2.0	0.9	21.7	9.2	2.9	1.7	2.7	2.5
N_0M_4	10.2	10.6	17.0	8.8	3.0	2.0	26.6	10.4	4.6	3.0	3.8	2.9
N_0M_5	9.2	7.4	8.2	4.4	1.0	0.6	17.6	4.1	1.8	0.7	1.1	1.4
N_1M_0	21.6	20.3	56.1	48.2	8.9	5.8	110.0	65.3	12.3	10.5	10.0	7.4
N_1M_1	14.4	11.7	54.5	42.2	6.8	4.4	46.1	19.1	7.9	6.5	6.1	4.7
N_1M_2	11.8	10.7	29.2	16.2	4.0	3.1	42.1	12.3	5.5	3.5	4.1	3.5
N_1M_3	11.3	9.2	21.2	11.7	3.2	2.1	23.2	10.9	4.0	2.0	3.2	3.0
N_1M_4	11.2	11.0	26.1	16.7	4.1	4.1	34.6	17.1	8.0	6.8	4.0	3.8
N_1M_5	10.0	8.9	15.2	8.2	2.5	1.0	19.1	6.6	3.0	1.0	2.2	2.2
N_2M_0	22.7	20.8	60.4	50.4	10.2	6.9	146.7	80.7	20.0	16.2	14.6	12.1
N_2M_1	14.7	11.9	56.1	44.0	7.2	5.4	66.4	24.1	12.1	9.4	8.4	7.0
N_2M_2	11.7	10.7	32.2	17.1	6.1	4.1	55.6	14.7	7.0	6.8	6.0	5.1
N_2M_3	11.3	10.0	22.0	12.5	4.1	2.9	36.1	12.0	6.1	4.8	4.1	4.1
N_2M_4	11.8	11.3	30.4	18.2	4.9	4.5	42.4	21.3	12.5	10.7	7.3	5.3
N_2M_5	10.2	9.1	18.3	11.4	2.9	2.0	28.0	7.2	5.2	3.0	2.6	2.9
LSD (0.05)	2.1	2.3	2.9	3.0	0.3	0.2	5.5	3.3	1.8	1.0	3.9	0.8

* $\sqrt{n+1}$ transformed values

APPENDIX-5

Effect of interaction between N and weed management practices on trunk girth, extension growth, pruning weight and yield

Treatment	Trunk girth (cm)		Shoot growth (cm)		Pruning weight (Kg)		Yield (kg)	
	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	38.5	39.6	9.2	9.6	0.8	2.0	21.9	24.3
N_0M_1	38.7	39.8	9.6	12.0	1.0	2.1	31.0	26.5
N_0M_2	39.0	40.0	9.7	12.5	1.3	2.8	28.7	33.3
N_0M_3	39.2	40.1	11.6	14.2	1.4	3.1	34.9	29.7
N_0M_4	42.6	43.4	10.1	10.2	1.6	3.1	29.7	26.1
N_0M_5	41.6	42.5	9.5	10.4	1.3	2.4	21.2	21.1
N_1M_0	44.7	47.0	13.9	18.0	1.3	2.6	35.1	28.6
N_1M_1	44.8	47.1	14.2	18.8	1.7	2.7	40.7	30.2
N_1M_2	45.0	47.2	14.4	20.0	2.4	2.8	37.8	35.2
N_1M_3	45.1	47.3	15.7	21.3	2.6	2.9	42.0	36.8
N_1M_4	47.7	50.3	14.1	18.4	2.6	3.2	38.4	32.1
N_1M_5	47.1	48.2	14.2	19.3	1.8	2.7	37.2	28.1
N_2M_0	48.8	49.7	14.7	18.8	1.6	2.2	38.8	29.4
N_2M_1	49.0	50.0	15.4	21.0	1.8	2.5	42.2	32.0
N_2M_2	46.1	50.1	15.7	21.1	1.9	3.2	40.9	36.3
N_2M_3	51.0	52.1	18.2	24.8	2.6	3.3	42.4	38.8
N_2M_4	54.3	55.0	15.2	19.4	2.6	3.2	40.9	32.8
N_2M_5	49.2	50.3	15.2	21.0	1.7	3.1	37.7	28.4
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

APPENDIX-6

Effect of interaction between N and weed management practices on weight and size of fruits

Treatment	Fruit weight (g)		Fruit size (cm)	
	1985	1986	1985	1986
N_0M_0	42.3	46.6	22.7	23.6
N_0M_1	49.9	52.0	21.3	22.4
N_0M_2	54.1	48.6	19.1	20.4
N_0M_3	54.0	50.4	19.2	20.2
N_0M_4	53.6	57.9	22.2	24.1
N_0M_5	69.0	52.0	23.0	23.1
N_1M_0	59.1	53.7	21.3	24.4
N_1M_1	61.2	53.8	22.1	23.1
N_1M_2	61.4	57.3	23.1	21.2
N_1M_3	68.7	57.0	22.5	21.1
N_1M_4	67.6	53.9	22.3	25.8
N_1M_5	71.0	53.6	21.4	25.0
N_2M_0	52.1	50.2	20.1	26.0
N_2M_1	62.2	50.5	23.6	24.3
N_2M_2	66.4	55.6	23.8	22.6
N_2M_3	61.6	55.6	20.8	22.2
N_2M_4	69.9	50.7	23.2	27.1
N_2M_5	72.2	56.9	23.7	26.1
LSD (0.05)	2.2	7.2	NS	NS

APPENDIX-7

Effect of interaction between N and weed management practices on physico-chemical characteristic of fruits

Treatment	Firmness (kg)		TSS (%)		Acidity (%)		Total sugars (%)		Reducing sugars (%)	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	5.1	4.7	12.2	11.4	0.73	0.64	8.0	9.0	4.4	5.5
N_0M_1	4.1	3.6	10.2	11.4	0.58	0.64	8.6	9.2	5.0	6.1
N_0M_2	4.1	3.4	10.6	11.5	0.60	0.65	9.1	9.8	5.0	6.0
N_0M_3	3.9	3.5	11.7	11.6	0.65	0.65	8.2	10.5	4.4	4.4
N_0M_4	4.3	4.0	11.1	11.5	0.64	0.60	7.8	9.5	4.7	5.7
N_0M_5	4.0	3.6	11.3	11.5	0.68	0.61	9.0	8.6	4.3	5.6
N_1M_0	4.5	4.3	12.4	11.5	0.69	0.59	10.5	9.2	4.3	5.4
N_1M_1	4.3	3.9	11.5	11.3	0.60	0.64	8.2	9.5	4.5	5.6
N_1M_2	4.2	4.2	13.1	11.4	0.71	0.62	7.5	9.6	4.7	5.7
N_1M_3	4.5	4.0	11.5	11.4	0.67	0.60	8.1	10.0	4.6	5.4
N_1M_4	4.8	4.3	12.1	11.4	0.68	0.61	7.2	8.5	4.5	6.6
N_1M_5	4.2	4.0	11.3	11.2	0.64	0.59	8.2	9.7	4.4	5.4
N_2M_0	4.4	5.4	12.7	11.5	0.58	0.63	8.9	9.0	4.1	5.1
N_2M_1	4.3	3.5	13.0	11.2	0.61	0.66	9.5	10.4	4.9	5.4
N_2M_2	4.3	3.9	13.2	11.3	0.63	0.64	9.0	9.8	4.5	5.6
N_2M_3	4.2	4.2	11.8	11.5	0.59	0.63	7.7	9.1	4.4	5.4
N_2M_4	4.8	3.9	11.4	11.3	0.70	0.64	7.9	8.7	4.5	5.5
N_2M_5	4.1	3.8	11.5	11.2	0.58	0.62	7.5	6.5	4.5	5.6
LSD (0.05)	NS	NS	0.5	NS	NS	NS	0.6	1.1	NS	NS

APPENDIX-8

Effect of interaction between N and weed management practices on macronutrient status of leaf(% dry weight)

Treatment	N		P		K		Ca		Mg	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	2.14	2.06	0.18	0.19	1.26	1.35	1.60	1.59	0.56	0.55
N_0M_1	2.22	2.18	0.21	0.21	1.67	1.70	2.25	2.28	0.61	0.67
N_0M_2	2.21	2.11	0.19	0.21	1.33	1.80	2.29	2.32	0.61	0.62
N_0M_3	2.42	2.37	0.17	0.20	1.74	1.77	2.28	2.31	0.66	0.68
N_0M_4	2.56	2.55	0.20	0.20	1.81	1.84	2.74	2.76	0.66	0.70
N_0M_5	2.19	2.22	0.19	0.20	1.37	1.38	1.57	1.73	0.65	0.57
N_1M_0	2.83	2.94	0.16	0.18	1.55	1.57	1.96	1.95	0.58	0.56
N_1M_1	3.04	3.03	0.19	0.20	1.60	1.58	1.58	1.97	0.65	0.62
N_1M_2	3.09	3.05	0.16	0.19	1.48	1.50	2.08	2.25	0.60	0.63
N_1M_3	3.08	3.24	0.19	0.20	1.56	1.61	2.15	2.32	0.67	0.68
N_1M_4	3.22	3.49	0.19	0.21	1.73	1.61	2.35	2.39	0.68	0.73
N_1M_5	2.83	3.16	0.19	0.20	1.55	1.58	1.93	1.60	0.55	0.68
N_2M_0	3.05	2.84	0.15	0.18	1.51	1.53	1.85	1.89	0.52	0.49
N_2M_1	3.39	3.16	0.20	0.21	1.39	1.43	1.75	1.80	0.61	0.63
N_2M_2	3.34	3.09	0.17	0.20	1.45	1.46	1.99	2.07	0.57	0.60
N_2M_3	3.44	3.27	0.15	0.19	1.69	1.49	2.11	2.25	0.63	0.65
N_2M_4	3.60	3.58	0.18	0.19	1.45	1.73	2.30	2.34	0.65	0.68
N_2M_5	3.37	2.96	0.18	0.20	1.36	1.37	1.45	1.51	0.58	0.60
LSD(0.05)	0.84	0.08	NS	NS	0.14	0.02	0.16	0.15	0.05	0.06

APPENDIX-9

Effect of interaction between N and weed management practices on the micronutrient status of leaf (ppm dry wt)

Treatment	Fe		Mn		Zn		Cu	
	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	164.7	163.2	52.7	50.0	11.5	11.2	5.6	4.6
N_0M_1	186.0	181.5	42.5	45.7	12.5	13.5	5.0	4.2
N_0M_2	163.0	158.7	39.7	41.5	10.2	12.2	4.3	3.6
N_0M_3	170.7	167.7	52.5	55.0	10.7	12.0	4.9	4.5
N_0M_4	176.5	171.2	62.2	65.7	14.2	15.5	6.1	5.5
N_0M_5	163.0	159.7	48.0	51.5	10.2	11.0	4.3	3.7
N_1M_0	187.7	191.0	65.2	67.7	13.2	14.0	5.3	4.9
N_1M_1	196.0	200.2	67.7	57.0	13.0	15.5	5.8	5.2
N_1M_2	184.5	189.7	51.0	53.2	13.2	13.7	4.8	4.2
N_1M_3	159.2	194.0	66.2	69.2	13.5	16.0	4.7	4.3
N_1M_4	189.0	195.5	98.2	76.0	14.7	15.0	6.7	6.1
N_1M_5	173.5	176.2	54.7	70.0	12.0	13.5	4.6	4.2
N_2M_0	187.5	191.7	62.7	66.0	13.0	14.5	4.6	4.1
N_2M_1	202.2	208.7	66.0	68.0	15.5	17.0	5.1	4.3
N_2M_2	186.7	190.5	54.2	56.7	14.2	15.0	3.9	3.6
N_2M_3	192.0	195.0	71.0	74.0	15.2	16.5	5.5	4.9
N_2M_4	187.7	191.0	90.5	88.5	15.5	17.0	5.6	5.2
N_2M_5	181.0	185.0	57.7	59.0	14.7	15.5	4.6	4.2
LSD(0.05)	NS	NS	6.3	6.3	NS	NS	0.6	NS

APPENDIX-10

Effect of interaction between N and weed management practices on macronutrient status of fruits (mg $100g^{-1}$ fresh weight)

Treatment	N		P		K		Ca		Mg	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	143.5	146.0	22.7	26.0	98.0	93.7	57.7	56.7	25.5	25.7
N_0M_1	146.5	147.0	22.7	26.2	133.7	126.5	73.2	74.7	23.7	25.0
N_0M_2	148.0	147.0	22.5	26.0	111.7	97.5	68.0	65.7	24.7	25.5
N_0M_3	153.2	158.7	22.7	26.2	115.5	108.7	63.5	58.2	37.2	28.0
N_0M_4	156.5	161.7	23.2	26.2	140.0	138.5	76.0	78.2	30.0	32.0
N_0M_5	133.2	138.7	22.0	28.7	124.7	123.7	58.0	57.5	23.2	22.0
N_1M_0	153.5	150.0	23.1	26.2	96.0	90.7	54.5	51.0	25.7	29.7
N_1M_1	154.5	150.5	23.0	26.2	126.0	104.1	69.5	64.5	23.2	29.5
N_1M_2	156.2	150.7	22.7	26.5	97.7	94.0	64.0	56.7	25.7	30.0
N_1M_3	159.2	152.7	23.0	26.7	113.0	100.7	58.7	48.7	29.0	30.5
N_1M_4	168.2	168.0	23.2	26.7	136.2	134.7	74.7	75.5	31.7	33.0
N_1M_5	140.0	149.0	22.2	26.0	121.7	117.0	53.7	51.0	24.2	28.5
N_2M_0	161.0	168.0	22.5	25.0	94.2	86.7	51.5	50.0	26.7	30.2
N_2M_1	161.5	162.0	23.0	25.2	124.7	102.2	65.7	58.2	23.7	30.0
N_2M_2	163.7	163.2	22.5	25.5	96.2	92.5	63.5	51.7	26.0	30.5
N_2M_3	164.5	165.5	23.0	26.0	111.0	92.5	59.2	49.7	27.7	30.7
N_2M_4	172.0	170.5	23.2	26.0	133.7	130.5	70.7	71.2	35.2	33.7
N_2M_5	147.0	153.7	22.0	25.0	121.2	111.0	51.0	45.7	24.5	29.5
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	4.5	NS	NS

APPENDIX-11

Effect of interaction between N and weed management practices on the micronutrient status of fruits(mg $100g^{-1}$ fresh weight)

Treatment	Fe		Mn		Zn		Cu	
	1985	1986	1985	1986	1985	1986	1985	1986
N_0M_0	0.79	0.72	0.11	0.10	1.50	1.12	0.20	0.16
N_0M_1	0.85	0.80	0.11	0.11	1.27	0.94	0.19	0.15
N_0M_2	0.91	0.85	0.12	0.09	1.30	0.97	0.18	0.15
N_0M_3	0.92	0.89	0.12	0.09	1.32	1.02	0.19	0.13
N_0M_4	0.93	0.90	0.13	0.14	1.62	1.22	0.20	0.18
N_0M_5	0.79	0.78	0.11	0.11	1.25	0.92	0.14	0.12
N_1M_0	0.85	0.84	0.13	0.11	2.25	1.25	0.18	0.14
N_1M_1	0.92	0.89	0.14	0.11	1.97	1.12	0.19	0.13
N_1M_2	0.93	0.91	0.15	0.09	2.15	1.15	0.19	0.13
N_1M_3	0.94	0.92	0.15	0.10	2.20	1.22	0.19	0.12
N_1M_4	0.96	0.93	0.16	0.14	2.42	1.30	0.19	0.17
N_1M_5	0.87	0.85	0.13	0.11	1.87	1.00	0.17	0.12
N_2M_0	0.87	0.87	0.14	0.11	1.67	1.12	0.18	0.14
N_2M_1	0.95	0.89	0.13	0.11	1.57	1.05	0.17	0.13
N_2M_2	0.97	0.93	0.15	0.10	1.62	1.12	0.16	0.14
N_2M_3	0.97	0.96	0.15	0.10	1.65	1.12	0.19	0.15
N_2M_4	0.99	0.99	0.17	0.14	1.80	1.15	0.22	0.18
N_2M_5	0.90	0.87	0.14	0.11	1.45	1.02	0.16	0.11
LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS

APPENDIX-12

Effect of N x M, N x D and M x D interaction on soil pH, electrical conductivity and organic carbon at different depths

Treatment	pH		Electrical conductivity (m mhos cm^{-1})		Organic carbon (%)	
	1985	1986	1985	1986	1985	1986
N x M						
N_0M_0	4.94	4.88	0.16	0.15	1.19	1.50
N_0M_1	4.88	4.21	0.18	0.17	1.17	1.40
N_0M_2	4.87	4.26	0.19	0.16	1.17	1.39
N_0M_3	4.82	4.16	0.18	0.17	1.30	1.39
N_0M_4	4.92	4.83	0.16	0.16	1.31	1.37
N_0M_5	4.93	4.83	0.16	0.15	1.21	1.44
N_1M_0	4.75	4.34	0.15	0.13	1.24	1.46
N_1M_1	4.73	4.16	0.17	0.14	1.09	1.44
N_1M_2	4.75	4.18	0.15	0.14	1.13	1.40
N_1M_3	4.61	4.12	0.18	0.17	1.10	1.30
N_1M_4	4.78	4.57	0.19	0.18	1.19	1.42
N_1M_5	4.79	4.58	0.16	0.14	1.01	1.34
N_2M_0	4.72	4.16	0.17	0.16	1.09	1.49
N_2M_1	4.58	4.08	0.19	0.18	0.98	1.23
N_2M_2	4.70	4.13	0.18	0.16	1.17	1.37
N_2M_3	4.41	4.04	0.20	0.18	1.13	1.35
N_2M_4	4.67	4.42	0.20	0.18	1.27	1.43
N_2M_5	4.72	4.46	0.17	0.16	1.08	1.35
LSD (0.05)	0.09	NS	0.02	0.02	0.15	0.17
N x D						
N_0D_1	4.66	4.33	0.12	0.11	1.50	1.84
N_0D_2	4.91	4.54	0.18	0.16	1.24	1.51
N_0D_3	5.11	4.71	0.23	0.21	0.94	0.90
N_1D_1	4.56	4.11	0.12	0.10	1.41	1.79
N_1D_2	4.72	4.38	0.17	0.15	1.16	1.46
N_1D_3	4.97	4.48	0.21	0.19	0.81	0.97
N_2D_1	4.45	4.08	0.14	0.11	1.42	1.79
N_2D_2	4.61	4.24	0.19	0.17	1.08	1.46
N_2D_3	4.83	4.33	0.23	0.21	0.87	0.97
LSD (0.05)	NS	NS	NS	NS	NS	NS
M x D						
M_0D_1	4.69	4.28	0.14	0.12	1.62	1.97
M_0D_2	4.82	4.70	0.18	0.17	1.05	1.57
M_0D_3	5.00	4.89	0.22	0.21	0.86	0.96
M_1D_1	4.56	4.05	0.12	0.12	1.29	1.79
M_1D_2	4.69	4.10	0.17	0.16	1.06	1.30
M_1D_3	4.94	4.30	0.20	0.20	0.89	0.89
M_2D_1	4.59	4.05	0.11	0.10	1.42	1.83
M_2D_2	4.79	4.13	0.20	0.17	1.15	1.43
M_2D_3	4.93	4.39	0.22	0.21	0.90	0.90
M_3D_1	4.39	4.01	0.10	0.16	1.48	1.93
M_3D_2	4.58	4.06	0.18	0.16	1.17	1.46
M_3D_3	4.87	4.24	0.23	0.21	0.93	0.92
M_4D_1	4.57	4.32	0.14	0.12	1.53	1.97
M_4D_2	4.00	4.66	0.18	0.18	1.30	1.46
M_4D_3	5.00	4.84	0.26	0.21	0.95	0.89
M_5D_1	4.62	4.34	0.12	0.11	1.36	1.69
M_5D_2	4.81	4.67	0.15	0.14	1.22	1.52
M_5D_3	5.00	4.80	0.20	0.19	0/71	0.91
LSD (0.05)	NS	0.11	0.01	NS	0.12	0.11

APPENDIX-15

Effect of N x M x D interaction on soil pH, electrical conductivity and organic carbon at different depths

Treatment	pH		Electrical conductivity (m mhos cm^{-1})		Organic carbon (%)	
	1985	1986	1985	1986	1985	1986
$N_0M_0D_1$	4.70	4.60	0.12	0.11	1.53	1.88
$N_0M_0D_2$	4.96	4.92	0.16	0.15	1.16	1.66
$N_0M_0D_3$	5.17	5.11	0.21	0.19	0.88	0.97
$N_0M_1D_1$	4.62	4.10	0.13	0.12	1.36	1.79
$N_0M_1D_2$	4.91	4.70	0.18	0.17	1.10	1.45
$N_0M_1D_3$	5.11	4.33	0.22	0.21	1.04	0.94
$N_0M_2D_1$	4.64	4.13	0.10	0.10	1.54	1.81
$N_0M_2D_2$	4.87	4.23	0.19	0.17	1.29	1.48
$N_0M_2D_3$	5.10	4.40	0.27	0.20	0.69	0.88
$N_0M_3D_1$	4.57	4.00	0.10	0.09	1.59	1.83
$N_0M_3D_2$	4.85	4.05	0.20	0.19	1.23	1.44
$N_0M_3D_3$	5.03	4.31	0.24	0.23	1.08	0.88
$N_0M_4D_1$	4.69	4.57	0.12	0.12	1.53	1.81
$N_0M_4D_2$	4.93	4.57	0.16	0.15	1.33	1.48
$N_0M_4D_3$	5.14	4.85	0.21	0.20	1.10	0.83
$N_0M_5D_1$	4.70	4.58	0.11	0.11	1.48	1.87
$N_0M_5D_2$	4.93	4.85	0.15	0.14	1.29	1.55
$N_0M_5D_3$	5.14	5.04	0.20	0.19	0.85	0.89
$N_1M_0D_1$	4.59	4.08	0.14	0.13	1.65	1.92
$N_1M_0D_2$	4.74	4.20	0.19	0.18	1.04	1.48
$N_1M_0D_3$	4.95	4.73	0.22	0.20	1.02	0.97
$N_1M_1D_1$	4.58	4.02	0.10	0.10	1.31	1.77
$N_1M_1D_2$	4.69	4.10	0.15	0.13	1.13	1.55
$N_1M_1D_3$	4.89	4.42	0.19	0.18	0.84	0.99
$N_1M_2D_1$	4.23	4.03	0.10	0.09	1.32	1.92
$N_1M_2D_2$	4.60	4.11	0.18	0.15	1.07	1.34
$N_1M_2D_3$	4.92	4.40	0.23	0.19	0.98	0.93
$N_1M_3D_1$	4.40	4.01	0.09	0.08	1.31	1.69
$N_1M_3D_2$	4.63	4.02	0.16	0.16	1.18	1.50
$N_1M_3D_3$	4.82	4.30	0.20	0.17	0.81	0.93
$N_1M_4D_1$	4.59	4.17	0.15	0.12	1.56	1.87
$N_1M_4D_2$	4.78	4.66	0.18	0.18	1.27	1.39
$N_1M_4D_3$	4.98	4.87	0.22	0.20	0.71	0.99
$N_1M_5D_1$	4.60	4.10	0.12	0.10	1.28	1.55
$N_1M_5D_2$	4.80	4.23	0.14	0.12	1.27	1.47
$N_1M_5D_3$	4.99	4.67	0.20	0.19	0.45	0.99
$N_2M_0D_1$	4.52	3.98	0.15	0.12	1.66	1.96
$N_2M_0D_2$	4.76	4.04	0.19	0.18	0.93	1.55
$N_2M_0D_3$	4.87	4.46	0.22	0.21	0.67	0.95
$N_2M_1D_1$	4.47	4.01	0.13	0.12	1.19	1.79
$N_2M_1D_2$	4.47	4.01	0.17	0.16	0.95	0.15
$N_2M_1D_3$	4.80	4.09	0.20	0.19	0.80	0.73
$N_2M_2D_1$	4.55	3.99	0.12	0.10	1.40	1.75
$N_2M_2D_2$	4.77	4.03	0.21	0.19	1.10	1.48
$N_2M_2D_3$	4.76	4.36	0.27	0.24	1.00	0.87
$N_2M_3D_1$	4.19	4.00	0.11	0.09	1.40	1.65
$N_2M_3D_2$	4.28	4.01	0.18	0.15	1.09	1.43
$N_2M_3D_3$	4.78	4.11	0.25	0.23	0.90	0.95
$N_2M_4D_1$	4.44	4.20	0.15	0.12	1.53	1.94
$N_2M_4D_2$	4.69	4.47	0.20	0.19	1.27	1.50
$N_2M_4D_3$	4.80	4.59	0.23	0.21	1.01	0.84
$N_2M_5D_1$	4.54	4.20	0.14	0.12	1.32	1.66
$N_2M_5D_2$	4.70	4.47	0.16	0.15	1.10	1.53
$N_2M_5D_3$	4.90	4.20	0.20	0.19	0.80	0.85
LSD (0.05)	NS	0.22	NS	NS	NS	NS

APPENDIX-14

Effect of N x M, N x D and M x D interaction on the available nutrient status of the soil (ppm)

Treatment	N		P		K		Ca		Mg	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
N x M										
N_0M_0	44.1	52.0	5.9	8.1	105.0	99.4	618.2	612.6	97.5	104.1
N_0M_1	50.2	55.6	6.0	9.5	109.5	105.4	619.1	616.0	99.5	111.5
N_0M_2	51.2	55.8	6.2	8.9	110.4	106.3	621.6	609.5	103.6	104.6
N_0M_3	82.6	71.7	6.4	9.5	111.8	109.0	621.4	617.0	101.8	109.4
N_0M_4	54.5	66.0	6.1	9.5	120.6	115.8	651.5	630.0	104.1	116.7
N_0M_5	50.4	53.8	5.9	9.0	103.3	102.5	622.3	607.9	98.5	104.8
N_1M_0	58.3	85.3	5.8	8.4	108.7	109.0	648.0	629.1	107.8	109.0
N_1M_1	58.3	100.9	6.2	8.9	116.5	116.4	644.5	627.3	107.3	117.0
N_1M_2	66.6	87.6	6.1	8.4	113.9	113.7	639.4	614.5	105.9	113.5
N_1M_3	96.7	114.6	6.4	9.7	120.4	119.8	627.2	644.0	108.0	120.0
N_1M_4	66.7	111.7	6.2	9.3	127.0	127.3	650.9	654.1	110.4	124.1
N_1M_5	63.9	105.9	6.2	9.4	112.6	109.6	627.7	620.9	108.9	115.1
N_2M_0	65.2	87.6	6.0	8.5	111.9	113.7	646.7	650.4	117.6	116.5
N_2M_1	65.9	99.3	6.2	9.2	114.8	114.9	647.3	658.3	120.0	119.7
N_2M_2	76.3	92.4	6.4	8.5	114.7	113.5	648.7	650.2	116.1	113.5
N_2M_3	84.4	116.2	6.4	9.4	119.2	121.1	140.6	666.9	122.0	123.1
N_2M_4	68.0	116.5	6.3	9.4	131.9	127.9	664.0	679.3	126.1	124.6
N_2M_5	66.7	110.1	6.2	9.0	110.0	115.1	684.4	653.1	110.5	115.3
LSD(0.05)	7.7	7.1	NS	NS	NS	4.0	NS	NS	7.8	5.5
N x D										
N_0D_1	69.6	68.0	8.8	12.4	138.2	137.6	654.5	655.7	111.8	110.3
N_0D_2	62.5	63.4	5.1	9.9	115.9	107.9	622.7	603.0	98.6	105.2
N_0D_3	34.5	45.8	4.4	4.3	76.2	73.4	602.8	587.9	93.1	100.0
N_1D_1	86.0	115.2	8.9	12.5	148.3	152.7	672.7	665.5	117.4	129.3
N_1D_2	79.4	108.8	5.2	10.3	118.0	117.2	634.7	623.3	107.8	115.4
N_1D_3	39.9	79.0	4.4	4.2	83.2	77.2	611.4	606.2	97.8	104.7
N_2D_1	89.6	117.4	9.0	12.5	150.3	155.5	672.6	673.3	130.6	129.1
N_2D_2	83.4	111.5	5.3	10.3	124.5	120.8	654.8	662.7	120.2	122.0
N_2D_3	42.3	83.1	4.4	4.2	76.5	76.7	620.5	643.0	105.2	105.2
LSD(0.05)	1.0	1.2	2.2	3.4	2.4	4.7	6.1	6.4	3.0	2.2
M x D										
M_0D_1	68.8	87.1	8.5	11.3	138.3	140.6	660.1	656.6	114.5	119.7
M_0D_2	62.9	80.3	5.0	9.3	112.0	107.9	641.0	628.3	108.0	110.9
M_0D_3	35.5	57.4	4.2	4.4	75.3	71.5	618.7	611.2	100.5	99.8
M_1D_1	75.5	100.8	8.8	12.2	143.0	148.0	662.0	662.3	119.8	130.7
M_1D_2	63.1	94.3	5.2	10.1	120.2	113.3	639.5	626.2	119.3	112.9
M_1D_3	35.8	61.7	4.5	4.0	77.6	75.3	611.4	609.1	97.7	104.5
M_2D_1	80.0	92.5	9.3	11.9	145.0	145.4	665.0	658.5	120.1	118.8
M_2D_2	73.8	87.1	5.2	10.0	116.0	114.3	630.8	615.0	107.6	110.8
M_2D_3	40.5	56.1	4.3	3.9	78.0	73.8	611.0	600.0	97.9	120.0
M_3D_1	107.9	112.7	9.5	13.8	150.4	153.0	670.2	674.2	122.5	129.0
M_3D_2	107.9	106.9	5.3	10.5	124.9	119.0	628.7	635.4	109.1	119.4
M_3D_3	57.0	85.0	4.4	4.4	76.1	77.9	590.3	618.3	100.2	104.2
M_4D_1	80.6	107.8	8.1	13.1	156.3	160.6	680.0	681.4	126.7	135.3
M_4D_2	75.9	105.6	5.3	10.6	133.7	126.5	653.3	650.4	104.1	121.6
M_4D_3	32.7	80.7	4.5	4.6	89.5	83.8	633.1	631.6	100.5	108.5
M_5D_1	77.4	101.2	8.6	12.7	140.6	146.0	661.7	655.9	116.0	124.1
M_5D_2	71.9	93.6	5.1	10.6	110.0	110.9	630.9	622.6	104.1	116.4
M_5D_3	34.8	74.9	4.5	4.1	75.4	73.8	605.8	603.3	97.6	100.7
LSD(0.05)	1.4	1.8	0.4	0.4	3.4	NS	8.6	15.7	NS	3.2

APPENDIX-19

Effect of N x M x D interaction on available nutrient status of soil(ppm)

Treatment	N		P		K		Ca		Mg	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
$N_0M_0D_1$	54.7	60.4	8.4	10.5	135.0	130.7	640.7	641.7	105.0	115.7
$N_0M_0D_2$	47.0	55.2	5.1	9.0	107.2	99.7	626.2	612.5	95.0	103.5
$N_0M_0D_3$	30.3	40.3	4.1	4.0	72.7	68.7	600.7	596.2	92.7	95.2
$N_0M_1D_1$	65.5	64.9	8.6	11.2	135.7	136.2	648.7	648.7	112.2	126.5
$N_0M_1D_2$	52.4	60.2	5.0	[illegible]	117.0	105.7	617.0	601.2	98.0	104.0
$N_0M_1D_3$	32.6	44.7	4.5	4.3	76.0	74.2	597.2	596.2	88.5	104.0
$N_0M_2D_1$	60.9	63.3	9.2	12.9	139.7	139.0	653.7	662.5	118.7	108.5
$N_0M_2D_2$	50.2	60.8	5.2	9.9	113.7	107.0	611.2	592.5	98.2	105.0
$N_0M_2D_3$	34.4	42.9	4.3	4.1	77.7	74.0	591.0	593.7	94.0	100.5
$N_0M_3D_1$	103.1	87.8	9.6	13.4	140.2	137.5	658.7	667.5	112.2	120.5
$N_0M_3D_2$	95.9	76.5	5.2	10.4	120.7	112.2	611.7	597.5	100.0	107.5
$N_0M_3D_3$	49.0	55.8	4.4	4.3	74.5	77.2	593.7	586.2	93.2	100.2
$N_0M_4D_1$	69.2	77.4	8.5	13.3	146.5	151.2	671.2	671.7	115.5	133.2
$N_0M_4D_2$	64.1	71.3	5.2	10.7	130.0	116.5	650.0	617.5	99.2	117.7
$N_0M_4D_3$	70.7	49.2	4.5	4.5	85.5	79.9	633.2	601.7	97.9	105.2
$N_0M_5D_1$	64.1	67.0	8.2	12.7	132.0	131.2	646.2	643.2	107.5	117.7
$N_0M_5D_2$	57.2	57.4	5.0	10.4	106.7	106.2	619.5	596.7	95.5	99.7
$N_0M_5D_3$	29.9	41.9	4.5	4.1	71.2	67.5	601.2	583.7	93.7	95.0
$N_1M_0D_1$	74.3	99.2	8.4	11.2	139.2	143.0	668.7	661.2	113.0	116.7
$N_1M_0D_2$	65.8	93.5	4.8	9.5	111.7	110.0	647.5	621.2	107.5	109.7
$N_1M_0D_3$	36.7	63.1	4.2	4.5	75.2	74.0	627.7	605.0	103.0	100.7
$N_1M_1D_1$	85.8	121.3	8.7	12.6	145.7	155.5	666.2	662.0	115.0	133.7
$N_1M_1D_2$	66.2	111.9	5.2	10.5	121.2	116.5	653.7	618.7	107.7	111.0
$N_1M_1D_3$	36.8	69.5	4.6	3.5	82.5	77.2	613.7	601.2	99.2	106.2
$N_1M_2D_1$	83.5	104.8	9.0	11.3	147.2	149.7	673.0	656.2	116.5	125.0
$N_1M_2D_2$	74.8	97.1	5.2	9.6	112.7	115.5	628.7	598.7	103.7	113.0
$N_1M_2D_3$	41.6	60.6	4.2	4.2	81.7	76.0	616.5	588.7	97.5	102.5
$N_1M_3D_1$	111.3	125.7	9.5	13.8	154.7	157.5	676.2	674.5	119.5	133.0
$N_1M_3D_2$	105.5	119.8	5.2	11.0	124.5	20.7	617.5	647.0	105.0	121.7
$N_1M_3D_3$	63.2	98.3	4.7	4.7	82.0	81.2	588.0	600.5	99.5	105.5
$N_1M_4D_1$	85.5	122.2	8.8	13.0	157.2	163.7	682.5	680.0	123.0	136.0
$N_1M_4D_2$	81.5	119.1	5.4	10.3	130.0	130.7	642.5	652.5	116.2	125.0
$N_1M_4D_3$	63.2	94.0	4.5	4.6	94.0	87.5	627.7	630.0	91.5	111.5
$N_1M_5D_1$	83.4	118.2	8.7	13.0	145.7	147.0	670.0	659.0	117.2	130.7
$N_1M_5D_2$	76.6	111.2	5.2	10.9	100.0	110.2	618.2	608.7	107.0	112.0
$N_1M_5D_3$	31.8	88.3	4.6	4.2	84.2	71.7	595.0	595.0	102.5	101.7
$N_2M_0D_1$	79.5	101.8	8.6	12.1	140.7	148.2	663.0	667.5	125.7	126.7
$N_2M_0D_2$	76.0	92.3	5.2	9.4	117.0	114.0	649.5	651.2	121.5	119.5
$N_2M_0D_3$	40.1	68.8	4.3	4.0	78.0	79.0	627.7	632.4	105.7	103.5
$N_2M_1D_1$	85.8	116.2	8.9	12.7	147.5	152.5	671.2	676.2	132.2	132.0
$N_2M_1D_2$	70.7	110.9	5.3	10.7	122.5	117.7	647.5	658.7	122.2	123.7
$N_2M_1D_3$	41.2	70.7	4.5	4.4	74.5	74.5	623.2	640.0	105.5	103.5
$N_2M_2D_1$	95.6	109.2	9.5	11.5	148.0	147.5	670.7	657.0	125.2	123.0
$N_2M_2D_2$	88.5	103.0	5.3	10.5	121.7	120.5	652.5	653.7	121.0	114.5
$N_2M_2D_3$	45.6	64.9	4.5	3.6	74.5	72.5	623.0	640.0	102.2	103.2
$N_2M_3D_1$	115.1	179.6	9.6	13.6	156.2	164.2	675.7	680.7	135.7	133.5
$N_2M_3D_2$	101.4	174.4	5.4	10.1	129.5	124.0	657.0	668.7	122.5	129.0
$N_2M_3D_3$	58.8	[illegible]	4.1	4.5	72.0	75.2	589.2	651.2	109.0	107.0
$N_2M_4D_1$	87.1	174.0	9.0	12.9	165.2	167.0	686.2	693.0	141.2	136.7
$N_2M_4D_2$	82.7	[illegible]	5.7	10.7	141.2	132.0	667.5	681.2	125.0	128.7
$N_2M_4D_3$	34.7	49.0	4.6	4.5	89.2	84.5	638.5	663.7	112.2	109.0
$N_2M_5D_1$	84.7	123.5	8.9	12.5	144.2	154.0	669.0	665.5	123.5	123.0
$N_2M_5D_2$	81.8	117.1	5.7	10.5	115.2	116.2	665.0	661.5	110.0	117.5
$N_2M_5D_3$	33.6	94.4	4.5	4.0	70.7	75.2	621.2	631.2	98.0	105.5
LSD(0.05)	2.4	3.1	NS	NS	NS	NS	NS/	15.7	NS	5.6